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THE "BRUSH" SYSTEM OF ELECTRIC LIGHTING.

THE Brush system of electric lighting, which during the last two years has in the United States of America been developed into a very important commercial industry, is one of the most interesting systems of illuminating by electricity that has yet been before the public, and we are glad to see that it is at last becoming more and more appreciated in this country, and promises under very able and influential management to take a leading position among the lighting systems of Europe. It has for upward of twelve months been employed for illuminating the terminus of the Great Eastern Railway at Liverpool Street, and it has within a few weeks been adopted by the Great Western Railway Company for their Paddington Station, and the Charing Cross terminus of the Southeastern Company is now illuminated by the same system. It is about to be applied to light a large area of the city of London, where it will be in competition with both the Siemens and Jablochkoff systems, each of which will have a district of similar area of the city to illuminate, so that the public will soon have an excellent opportunity of comparing it with all the important systems that have been introduced, for the Gramme system is at the same time to be employed at the Cannon Street Station, where the electric currents will be utilized in another distinctive form of lamp.

The Brush, like the Siemens system, includes both generator and regulator peculiar to itself, and may, therefore, be looked upon as complete in itself, differing in that respect from all those so-called systems which are represented by either a particular form of machine or a special arrangement of lamp, and like the proprietors of the Siemens system, the Brush Company manufacture their own carbons, making the whole installation still more peculiar to themselves.

The Brush machine, a general view of which is given in Fig. 1, possesses some points of resemblance to the dynamo-electric machines of Gramme and of Wallace-Farmer, as well as to the magneto-electric machines of M. de Meritens, while at the same time its principle of construction differs from that of all others, and confers upon it at once its special excellence and its originality.

Its point of resemblance to M. Gramme's machine consists in the fact that its armature is of annular shape, a form of construction first adapted to the purpose by M. Gramme some thirteen years ago. The Brush armature differs, however, from the Gramme ring in the arrangement and disposition of the helices of wire with which it is wound, as well as in the way in which the several coils are connected with one another. In the Gramme armature the coils are wound contiguously to one another, so as entirely to envelop the iron core, hiding it completely from view, and they are permanently connected to one another in consecutive series. In the Brush armature the diametrically opposite bobbins are alone permanently connected together, and a current gene-

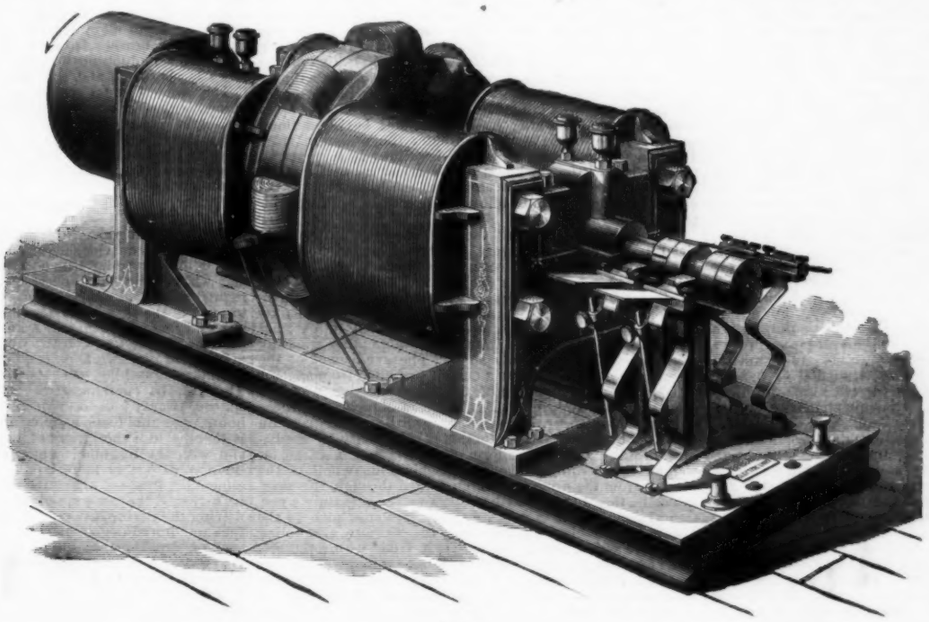


FIG. 1.

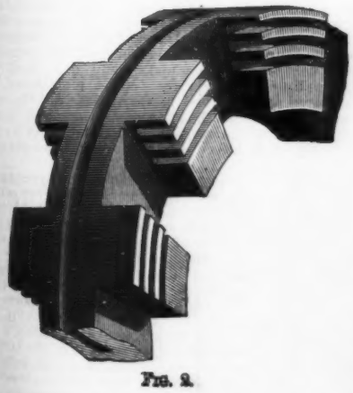


FIG. 2.

FIG. 3.

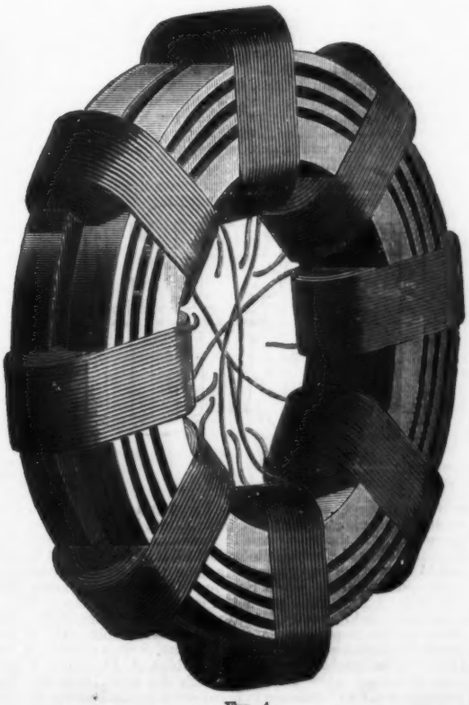


FIG. 4.

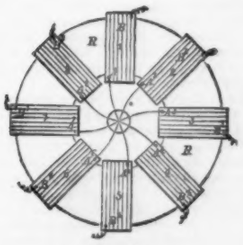


FIG. 5.

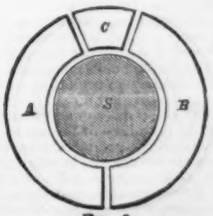


FIG. 6.

THE BRUSH DYNAMO-ELECTRIC MACHINE.

rated in one pair of bobbins does not necessarily traverse all the others, and, in fact, never does, as will be pointed out in the course of this notice. Again, the individual coils are separated from one another by a considerable sector of the iron ring, which is of larger sectional area between the coils (see Fig. 2), so that in the revolution of the armature within the magnetic field the coils alternate with masses of iron which from their enlarged section are brought into as close proximity to the poles of the field magnets as are the outsides of the coils themselves. It is this difference from the Gramme ring which constitutes the similarity between the Brush armature and that of M. de Meritens, but the Brush machine differs in all other essential respects from the latter machine in the disposition of its coils, in its method of connection, in the method and arrangement of the magnetic field, and in the continuous nature of its current.

The Brush machine, however, differs altogether from the Gramme generator in the disposition of its field magnets and the relative positions of the revolving helices and the magnetic field. In the disposition of its magnets the Brush machine more nearly resembles the Wallace-Farmer apparatus, but their form is entirely different, and the armature of the Wallace-Farmer bears no sort of resemblance to the Brush ring, its coils being more allied to those of M. Lontin's machine than to any other of the characteristic generators. Having thus pointed out the position occupied by the Brush machine with respect to other typical generators, showing wherein it approaches and wherein it departs from the machines of other systems, we will proceed to describe its construction.

The most characteristic feature of the Brush machine lies in the form and construction of its armature, which consists of a cast iron ring, the cross section of which is generally rectangular, but in the direction of its circumference it is alternately wide and narrow, as shown in the sketch, Fig. 2, which represents a portion of the iron armature ring and explains its construction better than can be given by description. On reference to this figure it will be seen that the ring is divided up into as many sectors as there are bobbins to be wound, by a number of rectangular depressions or grooves; in these the coils of insulated copper wire are wound until the groove is filled up and the flat converging recesses become flush with the face of the intermediate thicker portions or pole pieces by which they are separated from one another. Fig. 3 is a cross section of one side of the ring taken through one of these portions, and it will be observed on reference to both figures that the intermediate thicker portions of the ring are grooved out by a series of deep concentric grooves, the object of which is partly to reduce the mass and lessen the weight of the revolving armature, partly for the purpose of ventilating the ring and thus carrying away a portion of the heat generated by the working of the machine, but chiefly for the localization and isolation of local currents generated by induction in the iron, and which would tend not only to reduce the efficiency of the machine by diminishing the magnetic capacity of the armature, but also to produce a heating of the ring, and, therefore, of the coils, whereby a portion of the current would be lost through their resistance being increased. For a similar reason the periphery of the ring is grooved out deeply so as almost to sever the ring; by this means all cross currents are effectually cut off and induction currents are compelled to flow in directions which are not detrimental to the efficiency of the machine. This again increases the area of radiating or cooling surface, and consequently helps to prevent the armature becoming overheated.

In what is called the sixteen-light machine, which may be regarded as the normal size of the Brush generator, the armature ring is 20 in. in diameter, and it is wound with eight radial coils of cotton-covered copper wire, of No. 14 B.W.G., whose middle planes radiate from the axis of rotation, being distributed round the ring at equal angular distances apart of 45 degrees. Each coil contains about 90 ft. of wire weighing about twenty pounds, and is wound in the rectangular grooves or spaces shown in Fig. 2, filling up the space completely so that the vertical faces of all the coils are flush with the vertical faces of the thicker portions of the iron ring. Fig. 4 is a sketch of the armature ring with all its coils wound, which must be looked upon rather as an explanatory diagram than as an illustration of the proportions of this part of the apparatus. The two sides of each groove, and therefore of each coil of wires, are parallel to the center line or radial plane of the coil, and, by the adoption of that form of bobbin one of the practical difficulties in the winding of annular armatures of the ordinary form is avoided. All the coils are, like those in the Gramme machine, wound in the same direction

Fig 5 is a diagram illustrative not only of the distribution of the coils around the ring, but of the method by which the connections are made; the inner end of each of the coils is connected by a wire to the inner end of the corresponding coil, at the opposite end of the same diameter of the ring, and the outer ends of all the coils are brought through the shaft of the machine, and are connected to corresponding portions of the commutator, where the currents are collected by suitably placed copper plates or brushes. Referring to the diagram, it will be seen that the inner end, A^1, of the coil 1 is connected to A^5, which is the inner end of the coil 5; A^2 is connected to A^6, A^3 to A^7, and so on round the ring, and the outer ends, B^1, B^2, B^3, etc., are all connected to the commutator by conducting wires insulated from one another. The two free ends of each pair of diametrically opposed coils are, after passing through the shaft of the machine, attached respectively to two diametrically opposite segments of the same commutator, which segments are insulated from one another and from any other pairs of coils. The commutator, which is attached to and rotates with the driving shaft of the machine, consists of a set of separate copper rings or flat cylinders, of which there are as many on the shaft as there are pairs of coils on the armature, and each of these cylinders consists of two segments insulated from one another on one side of the shaft by a small air space about one-eighth of an inch wide, and on the other by a piece of copper separated from the segments by two smaller air spaces. The arrangement is shown in Fig. 6, in which A and B are the two segments connected respectively to corresponding coils on opposite sides of the armature, and attached by an insulating material to the shaft, S; C is the copper insulating piece, the object of which is to separate either of the flat copper brushes or collectors, which press upon the periphery of the commutator, from either of the segments during the interval occupied by one pair of coils passing the vertical, or in other words through the neutral portion of the magnetic field; this occurs twice in each revolution of the armature, and therefore of the commutator. At the time when any pair of bobbins is in this way cut out of the general circuit, their own circuit is open, so that no current can circulate or be induced in them. By this most ingenious arrangement each pair of coils has in succession in each revolution a period of rest equal to one-quarter of a revolution, and has a current passing through it for only 75 per cent. of the time the machine is running; to it is, in a great measure, due the very small development of heat in the working of the Brush machine, and it presents also another important element of efficiency to the machine, namely, that each pair of bobbins as it passes the neutral portion of the magnetic field, and is therefore incapable of doing work and contributing electromotive force to the general current, is itself cut out of the circuit, and thus two causes operating against the efficiency of the machine are eliminated; the first is one common to most armatures which have, like that in the Gramme machine, a permanently closed circuit, namely, that the currents generated in the bobbins have two routes open to them: the one through the conductors and commutators to the brushes, and the other through the idle bobbins, and thus by a species of short circuiting robbing the external circuit of some of its current. The other cause of inefficiency which is avoided in the Brush machine is the reduction of its internal resistance by an amount equal to the resistance of two of the bobbins, for just as a certain amount of resistance is an item of efficiency when belonging to coils which are doing work and contributing electromotive force to the general current, so does it become an element of inefficiency when belonging to coils which are idle, for in that case it diminishes the current supplied by the active coils while at the same time contributing no current of its own in compensation. By the arrangement of commutator referred to above, Mr. Brush has, therefore, got rid of two considerable drawbacks to the efficiency of the machine.

What is, however, one of the important features of the Brush machine is the arrangement of the magnets by which the magnetic field is produced, and by which the armature coils are during their revolution almost continually passing through a very intense magnetic field. Upon reference to Fig. 1 it will be seen that the armature ring is closely embraced on each side by the large horizontal electro-magnets whose poles are expanded so as to be presented to three of the armature coils on each side, leaving one pair of coils free from their direct influence, and this is the pair which is passing through the neutral region of the magnetic field. For the sake of illustration, the disposition of the magnets toward the armature and toward one another may be described as two horseshoe electro-magnets placed opposite one another in a horizontal position, their similar poles being presented toward one another, and having a small space between them in which rotates the armature ring. This space in the machines we are describing is, however, so nearly equal to the thickness of the armature that there is hardly any clearance between them, the high class workmanship of the apparatus allowing such close working with perfect safety.

The methods of exciting the field magnets in dynamo-electric machines are very different under different systems. In the early Gramme machines a separate armature was set apart for producing the current which by traversing the magnet coils produced the magnetic field between their poles, and the current from this armature had no other work to do, the useful or external current being taken direct from one or more other armature rings attached to the same shaft. The excitement of the magnets in one machine by a current supplied from another or from a special armature of the same machine was first suggested and employed by Mr. Wilde, of Manchester, whose name and that of Mr. Holmes must ever be associated with the early history of the production of electricity by mechanical means. In the later form of the Gramme machine, as well as in the ordinary Siemens machine, the whole of the current from the armature is transmitted through the magnet coils, they forming with respect to the armature a portion of the external circuit. In other systems, such as the Lontin, the Jablochkoff-Gramme, the Siemens alternating current machine, and in extensive installations of the Siemens machine, the field magnets of one or more generators are excited by the current from a special machine which has no other work to do; and in a special form of the Siemens machine the magnet coils form a shunt circuit to the armature, by which arrangement the machine acts to a great extent as its own regulator.

The system adopted in the Brush machine is, however, different to all to which we have just referred, while it has certain points of similarity to all. In the Brush machine the current contributed by each pair of bobbins on the armature is switched by the commutators alternately through the magnet coils and through the external circuit, so that each bobbin in its revolution "feeds" alternately the magnets and the lamps; and at any one position of the armature alternate bobbins are feeding the magnets while the rest are sending their currents to the "line," while at the next eighth part of a revolution, those which were feeding the line are switched

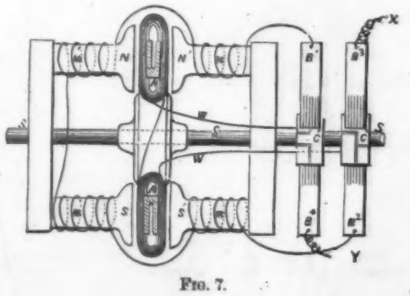


FIG. 7.

on to the magnets, and *vice versa*. Fig. 7 is a diagram illustrating the connection between the armature bobbins and the magnet coils at the time when the commutators are placing them in the same circuit. Referring to this diagram, M M and M M¹ are the two magnets having their similar poles presented toward one another on opposite sides of the armature coils, A A^3. Thus the coil A is under the influence of a magnetic field produced by the two north poles, N N^1, while at the same time its corresponding bobbin, A^3, is under the influence of the two south poles, S S^1; a current is therefore induced in the pair of bobbins, A A^3, which is transmitted by wires passing through the shaft, S, to the commutator, C^1 C^2, whence it is collected by the brushes, B^1 and B^2, and by them transmitted to the magnet coils, which are all connected together in series, and at the same time the other portions of the commutators (which are in connection with the other working armature bobbins) are in contact with the brushes, B^3 and B^4, by which they are placed into the external circuit of the machine.

One of the most original and interesting features of the Brush machine is the commutating apparatus, which by the simplest of mechanical means collects and distributes the currents from the active armature coils, sending them into the magnet helices or into the "line," according to their position in the magnetic field, and cutting out of circuit the armature coils one by one as they pass through the neutral region between the poles. The whole commutating apparatus is fairly represented on the extreme right of the general view of the machine (Fig. 1), and consists of two pairs of rings of the form shown in Fig. 6, attached to and revolving with the main shaft, and, therefore, their position is fixed with respect to the revolving armature of the machine. On to the cylindrical circumferences of these rings are pressed two pairs of copper collecting brushes, which rub tangentially against the commutator rings, one pair pressing above and the other pair pressing below, a line forming the points of contact being a diameter of the ring. The copper "brushes," as they are called, are flat strips of elastic copper about two inches wide, cut at the ends, which press against the rings into eight tongues, so as somewhat to resemble a grainer's comb, and each comb or brush is wide enough to cover or be in contact with two armature rings, and in this way, although two of the coils are insulated twice in each revolution, the main circuit is never interrupted. The disposition of the brushes with respect to the commutators will clearly be understood by comparing Fig. 1 with Fig. 7.

For the sake of adjusting the brushes so as to make contact with the commutators at the most effective angular position with respect to the magnetic field, they are mounted to the opposite ends of two rocking levers, which are capable of oscillating on the driving shaft, and can be fixed in any desired position by means of a set-screw, which clamps a stout wire rising from the base of the machine. The currents are conveyed from the brushes by wide strips of thin sheet copper, shown in the general view, and in order to allow for the variable distance of the free ends of the brushes from the base of the machine, they are made undulating or wavy, doubling up as the distance is shortened and stretching out when it is increased.

The average total resistance of the sixteen-light machines as now constructed is about eleven ohms, to which the eight coils of the armature contribute about five ohms, that is 0·625 ohm each, and the magnet coils about six ohms or 1·5 ohm for each helix—the resistance of the connections, conductors, contacts, etc., within the machine being inconsiderable.

THE LAMPS.

The regulating electric lamps designed by Mr. Brush are quite as much an element of the remarkable success of his system of electric lighting as are the machines themselves, and while their performance is surpassed by no other regulator, and although they contain special contrivances to enable them to maintain a steady arc when burning sixteen or more together in a single circuit, they are probably the simplest in construction of all arc regulators, involving no clockwork or complicated feeding mechanism, or indeed anything that is liable to become deranged. They can be constructed to burn continuously for eight, sixteen, twenty-four, or indeed for any desired number of hours, and the mere hanging of a lamp in its place puts it thereby into the circuit of the other lamps of the series, and with the machine; while, on the other hand, the extinction of one or more lamps, or, indeed, their removal altogether, does not affect the others except (if the machine be driven at the same speed) to make them brighter, but by driving the engine slower, and therefore using less steam, the same initial degree of illumination can be maintained in each of, say, fourteen lamps as if all the sixteen were in operation. The great simplicity of the Brush lamp consists in the fact that the feed is actuated by gravity alone, while it is controlled solely by the influence upon a bar of iron of a magnetic field, the intensity of which varies with the strength of the electric current passing through the lamp circuit. The general external appearance of three forms of Brush regulators is shown on the opposite page in Figs. 8, 9, and 10; the first representing the single carbon or eight-hour lamp, the second the double carbon or sixteen-hour lamp, with its glass globe removed; and the last is a sketch of a more ornate form of the double carbon lamp, the controlling apparatus being inclosed in a nickel-plated case. In all these lamps, which are designed for general illumination, the lower carbons are fixed, and as they burn away the upper carbons follow them, so the arc gradually descends, but for certain special installations, such as lighthouses or for purposes of projection, a focus-keeping arrangement has to be applied.

Like most of the modern electric lamps, the upper carbon descends by its own weight until it touches the lower carbon, and the circuit is thereby completed; the effect of this in the lamps we are describing is to cause a soft iron plunger to be drawn to a more or less extent within a hollow coil, or sucking magnet, as it is sometimes expressively called; and through the intervention of a lever and a most ingenious annular clutch surrounding the rod of the upper carbon like a washer, the upper carbon is lifted away from the lower, and the arc is established. As the carbons burn away, the arc has a tendency to become longer, and its resistance to increase, and this, by diminishing the strength of the current, diminishes the supporting power of the magnetic helix, allowing its plunger to descend, and, in so doing, to lower the carbon and shorten the arc until the proper strength of the current is restored, when the rising of the plunger once more holds the carbon in position. In the above very general description we have advisedly spoken of the influences as *tending* to produce the effects, for, as a matter of fact, so sensitive is the controlling apparatus to the smallest variation of current, that there is practically no reciprocating action, such as the above description might suggest, but the normal condition of the upper rod is to be slowly sliding through the clamp as the carbons become shorter, but if by any chance the rod slides a little too far, the clutch immediately raises it again and the carbons are adjusted to their proper distance.

All who are familiar with the great difficulties which hitherto have appeared to be almost inseparable from the burning of several arc lights in a single circuit, will know that a number of regulators, constructed from the above very general and incomplete description, and with no other controlling contrivance, would be totally incapable of burning uniformly in a single circuit, and it is the extremely simple and ingenious method by which each lamp controls itself independently of the action of all the others in the circuit, and yet dependently on the strength of the current in

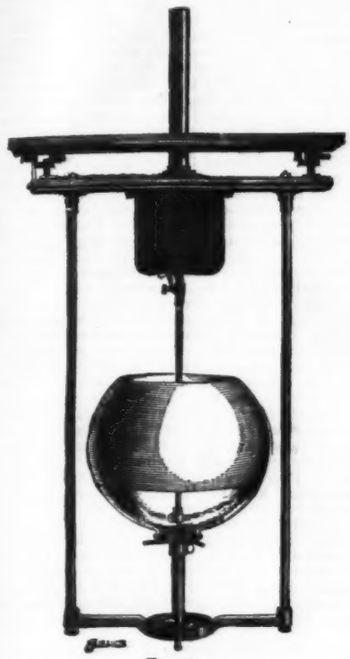


FIG. 8.

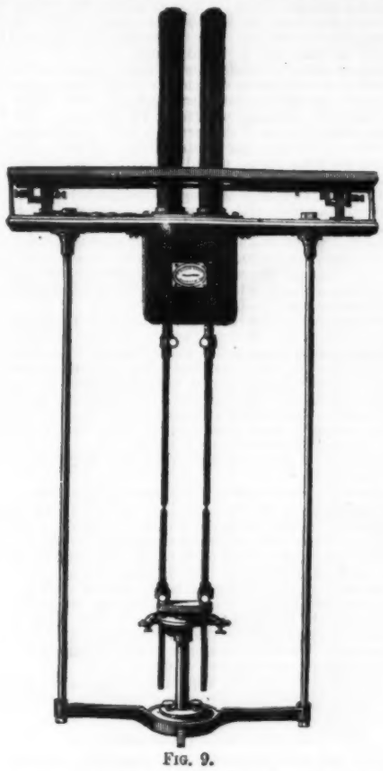


FIG. 9.

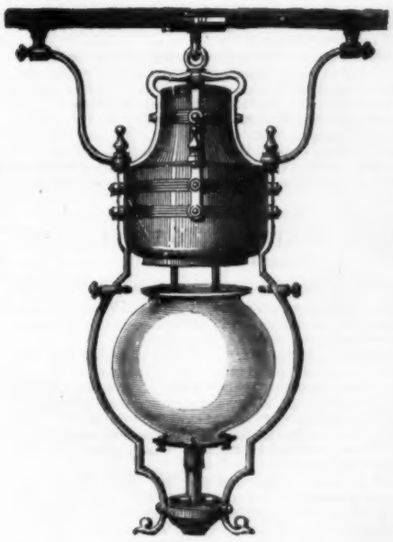


FIG. 10.

THE BRUSH ELECTRIC LAMP.

that circuit, that constitutes at once the great originality and the great perfection of the Brush regulator.

At first sight the problem might appear to be insoluble, but Mr. Brush has solved it in the following manner. Each of the bobbins of the controlling magnet is wound with two distinct coils of wire, the first consisting of a number of turns of thick wire, through which the current is transmitted to the arc, and the second of a much larger number of convolutions of fine wire which forms a secondary or shunt circuit between the terminals of the lamp, the connections being made in such a way that the electric current shall pass through it in a direction opposite to that in the primary of thick wire circuit, forming a shunt circuit of high resistance through the lamp, which, being always closed, is independent of the arc. It will readily be understood that, as the current flows in opposite directions around the magnet, the influence of the fine wire circuit will be to neutralize or weaken the attractive influence of the thicker helix, but the number of the convolutions of the two coils, as well as their respective resistances, are so proportioned to one another that the attractive influence of the primary helix (when the arc is of its normal length) shall overcome the influence of the secondary circuit. Owing to the greater resistance of the latter, not more than one per cent. of the main current is transmitted by the fine wire helix, but its magnetic influence is rendered considerable by its greater number of convolutions.

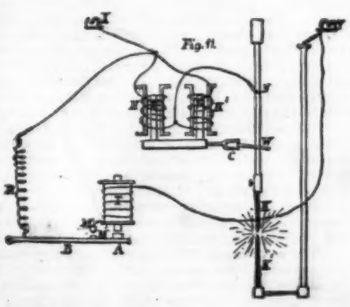


Fig. 11.

From the above description it is clear that since the electric current has two routes from one terminal of the lamp to the other, the one through the arc and the other independent of it, it follows that should the arc become too long, its resistance will increase, and a larger proportion of the current will be shunted through the fine wire helix, while the strength of that in the thicker helix will diminish, the resultant magnetic influence on the plunger will be reduced, and the upper carbon will be brought closer to the lower; on the other hand, if the arc becomes shorter than its normal length, its resistance is reduced, more current flows through the primary helix, and less through the secondary, and the carbons are drawn further apart.

Fig. 11 is a diagrammatic sketch showing the course of the primary circuit, and illustrating the general principle by which the arc is controlled; it also shows the short-circuiting contrivance by which any accident to one lamp or irregularity of working cuts it out of the general circuit, and does so without exercising any influence upon the other lamps in the series. In this diagram X and Y represent the two terminals of the lamp, which, in most cases, consists of hooks, which, by being dropped over pins attached to the ceiling—and which are in connection with the line circuit—place the lamp in circuit with the machine. The current entering at X is transmitted through the two hollow bobbins, H and H¹, in parallel circuit, the outcoming ends being joined together and connected to the upper carbon holder, N, and if the carbons are in contact, the current flows through them, and by the vertical rods of the lamp to the terminal hook, Y; the effect of this is to convert the solenoids, H and H¹, into magnets, which, by drawing into themselves the two iron plungers, N and S, lift one edge of the washer clutch, W, which, by its oblique action, seizes the carbon rod (much in the same way as a tent-rope tightener grasps its cord) and lifts the upper carbon until its influence is balanced by that of the fine wire helix, which, it must be remembered, surrounds the thicker coil.

The short-circuiting apparatus shown to the left of the carbons (see Fig. 11), consists of an electro-magnet, T, wound with a thick and a fine wire coil similar to those of the regulating solenoids, but both wound in the same direction. When the thick wire circuit of this magnet is complete, it forms a shunt of low resistance between the terminals, and, therefore, short-circuits the lamp, transmitting the current to the main circuit. Now, the fine wire wound upon this magnet is in circuit with the fine wire of the regulating solenoids; it follows, therefore, that if through a failure of the arc, or through its becoming abnormally long, or through any considerable increase in its resistance, a larger proportion of current be diverted through the fine wire circuit, the attractive force of the electro-magnet, T, would be increased and its armature, A, which is attached to the pivoted lever, B, would be attracted, the contact pieces, M and M¹, would thereby be brought together, and the terminals would be short-circuited through the thick coil, M, and the resistance spring, R. By thus short-circuiting the terminals through a route altogether independent of either the fine or the thick wire solenoids, their magnetic action ceases, and either the upper carbon is dropped, or, if it is burnt out, or from any other cause the arc is not established, the contact pieces, M and M¹, are held firmly together by the attraction of the magnet, T, and the current flows past the faulty lamp to the others in the series, its extinction calling attention to it, while the other lamps become proportionately brighter.

The carbon pencils consumed under the Brush system are, before being used, a foot long, and are electro-plated with a thin covering of copper; they last for about eight hours, during which time about 9½ inches of the positive and about 4 inches of the negative carbon are consumed. When, however, the lamps are required to burn for a longer period, double carbon lamps are employed, fitted with two pairs of carbon holders, as shown in Fig. 9, and each is controlled in the same way as in the single carbon lamp, but the controlling apparatus is not duplicated. When the lamp is put into action, the arc is formed between one of the pairs of carbons, and, when they have burnt out, the other pair automatically starts into action and continues to burn until it is in turn consumed; in this way the time of burning is doubled, and, in order to extend the period of burning, it is only necessary to employ a lamp with a third pair of carbons, when it will be capable of illuminating for twenty-four hours, each additional pair of carbons extending the period of burning for another eight hours.

The change from the one pair of carbons to the new pair is affected by purely mechanical means, and by a contrivance the ingenuity of which is only measurable by its extreme simplicity. This little apparatus will be understood by reference to the explanatory diagram, Figs. 12 and 13, which also more clearly illustrate the action of the washer-clutch than the preceding figure. C C is the hollow solenoid or "sucking magnet," which exercises a magnetic influence upon the soft iron plunger, P. The rising or falling of this plunger raises or lowers the little frame, K (shown in both figures), by the intervention of the lever, L. R¹ and R² are the carbon rods which pass vertically through the casing of the lamp, and W¹ and W² are the clutch washers which surround them. One side of each of these washers passes between a pair of jaws forming part of the little frame, K, and when the latter is drawn upward, its action is first to tilt the washers, and then to cause them to clutch the rod on diagonally opposite corners. By the very simple device of making one pair of jaws a little higher than the other it takes its grip before the other begins to act, and consequently lifts its corresponding carbon higher than its neighbor; the consequence is that only one arc is established, viz., across the lesser distance, and in all the subsequent feeding and controlling the pair of carbons first started are alone affected, because although both carbons are raised and lowered together, the lower end of the reserve carbon is always higher than the other by the difference in the height of the two pairs of jaws on the frame, K. A time arrives, however, when, owing to the shortening of the consuming carbons, they can no longer meet when the frame is dropped, and the current by which they are again separated can only be transmitted by the reserve carbons coming into contact; the circuit is thereby completed, the new carbons are separated, and the arc between them continues to be controlled by the magnet and clutch in the same way as the first arc was.

The great simplicity of the Brush lamp may not at first be appreciated from the above description, for in the action of

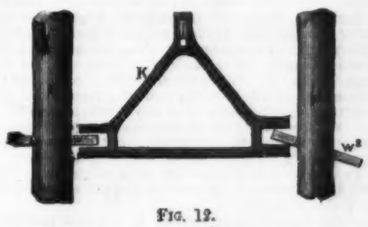


FIG. 12.

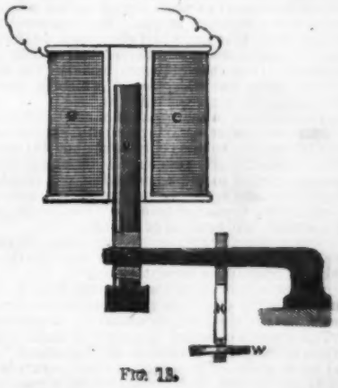


FIG. 13.

the lamp electrical phenomena of a somewhat complex nature occur, that is to say, the various courses of several different simultaneous circuits of different resistances have to be followed and considered, and this renders a description more complicated; but no one could examine a Brush lamp with its case removed or watch its action without being struck with its extreme simplicity and remarkable efficiency.

The Brush system of electric lighting is remarkable as being the only one which, to our knowledge, is capable of establishing a large number of large arc lights in a single circuit, and it would be difficult to over-estimate the great value of this distinctive property for the purpose of public illumination. Under other large arc systems each lamp must have a separate machine, and there must, of course, be as many lengths of leading wires as there are lamps and machines. It possesses also another very special advantage, and that is that a series of lights may be maintained by the Brush

system at a great distance from the machine, and with a remarkably small loss, and this is of especial advantage where several lights have to be employed, because if there are as many long conductors as there are lamps, then the whole of the loss of current due to the resistance of the cables must be borne by each lamp, whereas if a number of lights can be included in a single circuit, the loss of current from the resistance of conducting cables is equally divided among all the lamps in the series. There are, of course, commercial advantages in burning a number of lights in a single circuit from one machine, for there must necessarily be an enormous increase in prime cost in the adoption of a number of dynamo-electric machines in the place of one, as well as in the multiplication of conducting cables, and the advantage in point of attendance and repairs is obviously in favor of the single machine system.

With respect to the advantage of being able to operate a number of lights at a considerable distance from the machine, it is an interesting fact that the sixteen lights which are now in regular use for the illumination of Charing Cross terminus are actuated by a machine working in the Anglo-American Company's works in Lambeth, and that within a few weeks a large area of the City of London will be illuminated by the same system by forty lamps, all operated in one circuit by a machine working in the Lambeth works.—*Engineering.*

THE BRUSH SYSTEM OF ELECTRIC LIGHTING.

By Charles F. Brush, M. E.

PECULIAR FEATURES OF THE DYNAMO-ELECTRIC MACHINE.

The most prominent peculiarities of the Brush dynamo-electric machine are embodied in the armature, the arrangement of field magnets, and the commutator.

The armature consists of a flat ring of soft cast iron, revolving in its own plane. This ring is composed of two or more parts, each provided with a series of grooves, and insulated from each other, all in such a manner as effectually to prevent the induction of currents in the iron itself when it is revolved in a magnetic field. On this ring are wound eight bobbins of armature conductor, whose planes radiate from the axis of rotation.

The field magnets of the machine face both sides of the armature, in the plane of its rotation; thus both sides of the flat bobbins of armature conductor are exposed to the direct inductive influence of the magnets. This arrangement of armature and magnets differs radically from that adopted in the Gramme machine, the only other dynamo-electric machine of note in which an annular armature is employed.

Field magnets of opposite polarity are applied to diametrically opposite points of the annular armature, which then consists practically of two semicircular magnets, having their like poles joined. Each of these semicircular armature magnets, if straightened out, would be much longer than its own diameter, and would have its bobbins wound at right angles to its axis, and covering the greater part of its length. Now it will be evident, that with a given length and weight of armature conductor, a very much greater number of convolutions may be formed on such an armature than would be possible on other armatures whose length from pole to pole is short compared with their diameter. But inasmuch as the field magnets are applied to both sides, and very nearly the whole length of the long armature, the magnetic field in which the bobbins of conductor move is quite as intense as that obtainable when any other form of armature is employed, and perhaps more so; hence the electro-motive force of current obtainable with an armature conductor of given resistance is, *ceteris paribus*, very much greater with this form of armature than with any other. For a practical demonstration of this let us consider the brush machine known as size number 7. In this machine the resistance of the armature conductor, measured through the brushes on the commutator (the resistance is the same in all positions of the commutator), is about four ohms; in some machines a trifle more, in others a trifle less, according to the purity of the copper wire employed. When the armature is rotated at its normal speed of seven hundred and fifty revolutions per minute, in its normal magnetic field, the electro-motive force developed in its conductor is sufficient to maintain its normal volume of current through an external resistance, including the field magnets of the machine, of fully eighty ohms; or through a resistance twenty times as great as its own. No other form of dynamo-electric machine has yet shown a result comparable with this.

This current operates from sixteen to eighteen powerful electric lights arranged in a *single circuit*, giving to each an arc of about two millimeters length. The resistance of these arcs averages about four and a half ohms each, as shown by many careful measurements of different lamps, both singly and in groups. (The measurements included the magnet helix of each lamp, the resistance of which is, however, quite small, and will be given further on.)

The bobbins of wire on the armature of the Brush machine are not connected together in a single circuit, but each pair of diametrically opposite bobbins only, are connected together. The two free ends of the conductor thus formed of each pair of bobbins are carried to the commutator and attached to diametrically opposite segments thereon, which segments are not connected with any other bobbins. Thus each pair of bobbins is entirely independent of any other pair.

In this arrangement, which secures important advantages, the Brush machine again differs radically from the Gramme, and all similar continuous current machines.

The commutator consists of four separate rings of metal, each ring consisting of two nearly semicircular segments, whose ends, on one side, are separated by a considerable space. This space is occupied by a piece of metal attached to an adjoining ring, and known as an "insulator." It is insulated by an air space from each of the segments between whose ends it is located, the other ends of the segments being simply separated by a single air space. The office of the "insulator" is to separate either of the brushes which collect the currents from the commutator, from both segments during a certain interval, and twice in each revolution of the commutator. During these separations, the two bobbins of wire on the armature which are connected with the pair of segments, are not only out of the general circuit, but are open circuited themselves, so that no current can circulate in them.

Each pair of bobbins on the armature is thus provided with a commutator ring, and the segments of this ring occupy the same angular position with regard to other segments that its bobbins occupy with regard to bobbins attached to the said other segments.

It will now be seen that only one pair of armature bobbins is out of the general circuit at one time; and this is made to occur when the said bobbins are at and near the neutral points of the armature, and are not in a condition to contribute to the general current. Now, if it were not for the "insulators" above described, the idle bobbins would afford an easy passage for the current from the active bobbins, and thus destroy the efficiency of the apparatus.

The Gramme form of commutator, which is employed for the production of continuous currents in all machines other than the Brush, involves serious disadvantages from which the Brush form of commutator is free. The principal difficulty arising from the use of the former is this: The bobbins of wire, when at and near the neutral points of the armature, contribute little or no useful effect; but the current from the other bobbins must pass through them in order to reach the brushes, thus experiencing a considerable and entirely useless resistance, and, owing to the opposite directions of the currents through the active bobbins on opposite sides of the neutral points, these currents, by passing through the idle bobbins, tend strongly to produce "consequent" points in the armature where the neutral points should be; thus interfering seriously with the proper distribution of the armature's magnetism.

It may be argued that the evil above indicated is eliminated by allowing each of the brushes to embrace several sections of the commutator, corresponding to bobbins on both sides of each neutral point; this is, no doubt, true to some extent, but another and perhaps worse evil is thus introduced; the bobbins corresponding to the commutator sections embraced by each brush are short circuited in themselves, through the brush, and, owing to their comparatively small resistance, powerful currents are developed in them. These currents absorb much motive power in their production, and rapidly heat the bobbins.

Again, during each revolution of the Gramme commutator, each brush must break and make again as many contacts as there are sections of the former, and each act involves the whole current; while with the Brush commutator, only two contacts and breaks occur with each brush in each revolution, and these successively in the different rings, so that but one-fourth of the whole current is involved at one time.

Further, the use of oil for lubrication, appears to be impracticable with the Gramme form of commutator, while it may always be employed on the Brush commutator with great advantage. Thus the durability of this commutator is made immensely greater than that of the other.

When necessary, the wearing segments of the commutator may be replaced by duplicate pieces in a very few minutes by any mechanic

PECULIAR FEATURES OF THE LAMPS.

These are—very great simplicity of construction: insuring ease of management, safety against internal derangement, and securing great regularity of working; the double magnet circuit conveying currents of opposite direction, by means of which any number of lamps may be operated in a single circuit without any irregularity of action; the short circuiting safety attachment, by which any lamp offering an abnormally great resistance, owing to the final consumption of its carbons, or other cause, will, without any change of strength in the main current, automatically short-circuit the said lamp, and thus preserve the integrity of the general circuit; the multiple sets of carbons, burning successively, without the intervention of any switching or other special mechanism, and yet securing the maintenance of the light for any desirable length of time without requiring attention; lastly, the absence of any adjustment to be made by the attendant other than placing the carbons.

These lamps contain no clockwork or similar mechanism of any kind. The movement of the upper carbon, actuated by gravity, is controlled by a simple annular clamp which surrounds the rod carrying the carbon. When the lamp is in operation, one side of this clamp is lifted by magnetic action; this causes it to grasp and raise the rod, and thus separate the carbons. As the carbons burn away, the magnetic action diminishes, and the clamp and rod move gradually downward, maintaining only a proper separation of the carbons; but when the tilted annular clamp finally touches the supporting floor from which it started, any further downward move will at once release the rod and allow it to slide through the clamp, until the latter is again brought into action by the increased magnetism due to the shortened arc between the carbons. In continued operation, the normal position of the clamp is in contact with its lower support, the office of the controlling maguet being to regulate the sliding of the rod through it. If, however, the rod accidentally slides too far, it will instantly and automatically be raised again, as at first, and the carbon points thus maintained in proper relation to each other.

Each magnet helix is first wound with a few layers of coarse wire, through which the main portion of the current operating the lamp passes. Over this coarse wire is wound a very much greater length of fine wire, having its ends connected with the terminals of the lamp, but in such a manner that the electric current shall pass through it in a direction opposite to that in the coarse wire helix. Thus the fine wire forms a secondary circuit of high resistance through the lamp, which circuit is independent of the arc between the carbons, and is always closed. It follows from the difference in direction of the current in the two helices, that the fine wire helix will constantly tend to neutralize the magnetism produced by the coarse wire or principal helix. The number of convolutions of the fine wire helix and its resistance are so proportioned to the number of convolutions in the principal helix, and its resistance together with that of the normal voltaic arc, that the magnetizing power of the latter shall be much greater than that of the former. Notwithstanding the small amount of current which passes through the fine wire helix (about one per cent. of the whole current) its magnetic power is very considerable, owing to its great number of convolutions.

Now, when a number of regulators provided with these double helices are operated in a single circuit, great uniformity of action will be maintained owing to the peculiar function of the secondary helix. Thus, when any lamp gains more than its normal arc, the resistance of its main circuit is thereby increased; more current is consequently shunted through its secondary helix, and the resultant magnetism is diminished, allowing the carbons to approach. On the other hand, if an arc becomes too short, its resistance is reduced, and less current is shunted through the corresponding secondary helix; consequently the working magnetism in that lamp is increased and its carbons are drawn further apart. Thus it will be seen that, although the general strength of the current operating a large number of these lamps does not vary, each lamp performs its regulating functions through the agency of varying magnetism, precisely as though it were the only lamp being operated.

In practice, the resistance of the fine-wire helix or helices in each lamp is rather more than four hundred and fifty ohms; while the resistance of the coarse wire, various connections, carbons, and voltaic arc, in each lamp used with the sixteen-light machine, is about four and a half ohms. Hence not more than one per cent. of the whole current is diverted from the arc. The resistance of the coarse-wire helix, carbons (copper-coated), connections, etc., in each lamp is very small. To determine this resistance, sixteen lamps were connected in series in the usual manner, about two hundred feet of No. 10 copper circuit wire being used. Full-length carbons were then placed in the lamps, and the upper and lower carbons of each lamp were connected by means of a strip of sheet copper wired to each carbon. The resistance of the whole set was then measured, and found to be 2·10 ohms, showing a resistance for each lamp, with its carbons, of 0·131 ohm. This is 2·91 per cent. of the whole resistance of the lamp when in operation. To this loss must be added the one per cent. due to that amount of current diverted from the arc by the fine-wire regulating helix, making a total loss of 3·91 per cent. The remaining 96·09 per cent. of the whole energy absorbed in each lamp appears in the arc between its carbons.

The shunting or short-circuiting device in each lamp consists of a small magnet core, surrounded by a coarse and a fine wire helix, similar to those of the working magnet. No current passes through the coarse wire until the magnet which it surrounds has raised its armature. The latter, together with the coarse wire, then form a part of the short circuit established through the lamp. The fine-wire helix of the shunt is put in the circuit of the fine-wire regulating helices before described. During the normal operation of the lamp this fine-wire helix exercises a magnetizing influence on its inclosed core, which thus attracts its armature with a certain degree of force, but not enough to lift it. But when, through the exhaustion of the carbons in the lamp, or from their failing properly to feed together, the arc between them becomes considerably lengthened, thus developing an abnormally great resistance in the lamp, a greatly increased current will be shunted through the fine-wire helix, the iron core of the latter will raise its armature, and thus establish a circuit of low resistance through the lamp, independent of its carbons.

Evidently, when the short circuit is closed as above, very little current circulates in the fine-wire helix, and the magnet would drop its armature and thus open the circuit, were the armature not retained by some means other than the magnetism due to this helix; but it will be remembered that the coarse-wire helix surrounding the same iron core is now brought into action, and by this means the armature is retained.

This simple cut-out mechanism effectually guards against all the dangers of general extinction, which are always present when many lamps are burned in a single circuit. It will be noticed that it operates without any change in the strength of the general current operating a system of many lamps; and herein lies its great merit. No effect is produced in any lamp other than the faulty one, except a slight increase of brilliancy after the "cut-out" of the latter has acted. The extinction of a lamp necessarily calls attention to it at once, and the renewal of its carbons may be effected in a few seconds. As soon as the renewed carbons come into contact, a considerable portion of the current through the lamp is diverted from the magnet of the cut-out device by the passage afforded through the carbons; thus the retaining magnet is so weakened that it drops its armature and restores the whole current to the carbons, and the light is re-established.

The carbons employed in these lamps are covered with a thin coating of copper, and are twelve inches long. They burn without renewal about eight hours, during which time about nine and a half inches of the positive and four inches of the negative are consumed.

When it becomes desirable to operate the lamps more than eight hours continuously, "double-rod" lamps are used. In each of these lamps two movable rods and two sets of carbons are employed. The rods are placed three inches apart, and each is moved and controlled in the manner already described. But both rods are actuated by a single magnet, the same as that employed in the single-rod lamp. The simple lifting mechanism connected with the magnet is so arranged that one of the rods is lifted slightly in advance of the other. Now, when the electric current first passes through such a lamp, the two sets of carbons, having their members in contact, will divide the current between them; but as soon as the members of one set are separated by the action of the magnet, the whole current is thrown through the other set without showing any spark between the members of the set first separated. When the continued action of the magnet separates the remaining pair of carbons the voltaic arc appears and the light is established. It must now be evident that the clamp, which was the last to raise its rod, will be the first to release it when a forward movement of the carbons becomes necessary. Hence, the set of carbons which first commenced to burn will continue to do so until consumed, the other set remaining separated as at first. But when the burning carbons are exhausted and can no longer move forward, any further effort of the magnet to feed them will at once bring the reserve set of carbons into contact; the whole current will then pass through this set, leaving the other carbons without current and permanently separated. The reserve set of carbons will now be separated by the magnet and burn continuously. In practice, the transfer of the voltaic arc from one set of carbons to the other is accomplished instantaneously, and is scarcely noticeable.

It will be seen that this simple arrangement cannot possibly fail in its function, there being no switch to get out of order or contact surfaces to become burned; further, that it is perfectly automatic, and operates at the instant a change becomes necessary, and not sooner.

By means of these double-rod lamps a system of lights may be maintained in continuous operation sixteen hours without requiring any attention. This is sufficient for the longest winter night. But by introducing three rods and three sets of carbons in each lamp the lights may be maintained quite as easily and certainly for twenty-four hours. In this case the clamps lift their rods successively and feed them in the reverse order, as before.

A notable feature of the Brush lamp is the absence of any adjustment requiring the attention of the user; he has but to insert the carbons, and the lamps are always ready for action.

RESULTS ATTAINED.

On August 22, 23, and 25, 1879, a system of very careful measurements, both electrical and dynamic, were made by thoroughly competent persons for the purpose of accurately determining the efficiency of the Brush machine and lamps. These measurements were made at the works of the Telegraph Supply Company, Cleveland. The machine used was of the size known as No. 7, its individual mark, distinguishing it from other machines of the same class, being "Y." This

machine differed in no respect from others of the same size, and there is no reason to suppose that its performance was above or below the average. Sixteen lamps of the usual pattern were employed, with about two hundred feet of copper line wire No. 10.

The machine was driven by a "Buckeye" engine, with automatic cut-off, running at a speed of 157 revolutions per minute. This gave to the machine an average speed, during all of the experiments, of 770 revolutions per minute. The normal speed of these machines is 750 revolutions per minute, at which speed they operate sixteen lamps normally, giving to each an arc of about two millimeters length. At the speed at which these measurements were made the sixteen arcs were perceptibly lengthened, and, of course, more than the normal amount of driving power was required. But as this produces a nearly corresponding increase of current, no attempt was made to bring the speed nearer to the normal point, because of the difficulty of changing the speed of the engine.

The machine being entirely new, the bearings heated considerably. Some driving power must have been wasted on this account.

The first electrical measurements made were for the purpose of determining the difference of potential existing at the terminals of each lamp. This was done by a method devised by the writer. A battery of 48 small Daniell's cells was constructed on the "gravity" plan, carefully insulated, and freshly charged with sulphates of copper and zinc to insure normal action. The sixteen lamps having been adjusted to furnish arcs as nearly equal as possible, the positive terminal of one lamp was connected with the positive terminal of the battery; while the negative terminal of the same lamp was connected with the negative end of the battery, a very sensitive galvanometer being interposed. Now, it is evident that, if the difference of potential between the ends of the battery is greater than that between the terminals of the lamp, current will circulate in its normal direction through the battery, and will be indicated by the galvanometer; but if this potential is less than that of the lamp, current will also flow through the battery, but in a reverse direction, and will also be indicated by the galvanometer; while if the potential is the same in both, no current will pass in either direction through the battery, and the galvanometer will show no deflection.

As was expected, the potential of the battery proved to be higher than that of the lamp. By means of a simple arrangement any number of the battery cells could be included in the circuit at pleasure. Such a number was chosen that the galvanometer indicated no current, or currents fluctuating from zero, equally in both directions. The appearance of the arc in the lamp was then carefully noted and the speed of the machine counted. From time to time the condition of the arc would change slightly, or the speed of the machine would vary a little, and then more or less battery would be necessary to effect the balance. When such changes occurred, another set of observations was made as before, and so on, until results corresponding to the average working of the lamp were secured. The large number of observations made sufficiently eliminated the error due to the fact that no fraction of a single cell of the battery could be used in the experiments. This method of measuring the difference of potential between the terminals of the lamp proved to be extremely satisfactory and certain in its operation; the addition or subtraction of a single cell of battery being sufficient to deflect the galvanometer needle strongly to the right or left.

A series of observations was thus made on each of eleven of the sixteen lamps, selected at random, and as the results obtained from the various lamps agreed very closely, it was deemed unnecessary to carry the process further.

The difference of potential between the terminals of the *average* lamp was thus found to be equal to that of 42·46 cells of the battery, at an average speed in the machine of 770 revolutions per minute.

The next point to be determined was the resistance of the average lamp. For this purpose a resistance, consisting of coils of coarse copper wire, was substituted for one of the lamps, and made of such amount that 42 cells of the battery exactly balanced the difference of potential between the two ends of the resistance, while the speed of the machine was 770. This resistance wire weighed nearly seven hundred pounds, and was but slightly warmed during the experiment. Its resistance was then *immediately* measured with much care before any appreciable cooling could take place, and was found to be 4·51 ohms. From this resistance, balancing 42 cells of the battery, the resistance of the average lamp, corresponding to 42·46 cells of battery, is easily deduced, and is found to be 4·56 ohms. This, multiplied by sixteen, the number of lamps in circuit, gives the total resistance of the lamp circuit—72·96 ohms. The resistance of the conducting wires between the machine and lamps was not measured, being so small as to be unimportant. The average total internal resistance of the machine, measured through the brushes, with the commutators in various positions, and all of the conductors warm from active use, was found by careful measurement to be 10·55 ohms. Variations of only about 0·02 ohm were observed when the commutator was turned in different positions. This resistance, added to that of the lamps, gives a total normal internal and external resistance of 83·51 ohms, 87·36 per cent. of which (72·96 ohms) is external. Hence, 87·36 per cent. of the current developed by this machine is available for external work.

We have found that the electro-motive force of the current, overcoming a resistance of 4·56 ohms (the resistance of one lamp), is equal to that of 42·46 cells of battery; hence the total electro-motive force of the current, overcoming the total resistance, is

$$\frac{42{\cdot}46\times 83{\cdot}51}{4{\cdot}56} = 777{\cdot}59 \text{ cells.}$$

Assuming the electro-motive force of each cell of battery to be 1·079 volts, the electro-motive force is $777{\cdot}59 \times 1{\cdot}079 = 839{\cdot}02$ volts. By Ohm's well-known formula, the current in circulation is

$$\frac{839{\cdot}02}{83{\cdot}51} = 10{\cdot}04 \text{ webers.}$$

We have next to determine what portion of the energy of the whole current was utilized in the sixteen voltaic arcs for the development of heat and light. To this end the resistance of the sixteen lamps, including all connections, magnet wires, carbons, etc., minus the resistance of the arcs, was determined in the manner already described, and found to be 2·1 ohms. This, subtracted from the total resistance of the lamps, 72·96 ohms, leaves 70·86 ohms as the resistance of the sixteen arcs. This is 84·85 per cent. of the resistance of the entire circuit; and as the work performed by the current in any part of the circuit is directly as the resistance of the said part, it would appear that 84·85 per cent. of the entire energy of the current was expended in the arcs. But this is not the case, because 1 per cent. of the current passing through each lamp is diverted from the arc by the fine-wire adjusting helices, as before explained. Deducting 1 per cent. of 84·85, we have left 84, expressing the percentage of the entire energy of the current appearing as heat and light in the arcs.

The electrical measurements above described were made in the presence and with the assistance of Mr. G. H. Wadsworth, Chief Operator and Electrician of the Western Union Telegraph Co.'s Cleveland office.

The instruments used in measuring resistances were a tangent galvanometer by Phelps, and a set of standard resistance coils rating from 0·01 ohm upward. The measurements were made by substitution.

During the progress of the electrical measurements above described, a system of careful measurements of the driving power absorbed by the machine was also made. This was done by Mr. Isaac V. Holmes, of Cleveland, a gentleman widely known as a mechanical engineer and expert. His measurements were made from indicator diagrams taken at the cylinder of the engine, and covered a period of about three hours.

The following table embodies the results obtained by Mr. Holmes:

Total power developed with the 16 light machine at 770 revolutions "closed"	18·73 H. P.
Less friction load of engine "light"	2·44 "
" " due to increase of load (18·73—2·44=16·29) at 5 per cent.....	0·81 "
Total power absorbed by 16 light machine at 770 revolutions "closed"	15·48 "
Total power developed with the 16 light machine at 770 revolutions "open"	4·23 H. P.
Less friction load of engine "light"	2·44 "
" " due to increase of load (4·23—2·44=1·79) at 5 per cent	0·09 "
Total power absorbed by 16 light machine at 770 revolutions "open"	1·70 "
Total power absorbed by 16 light machine at 770 revolutions, in the production of current (15·48—1·70).....	13·78 "

NOTE.—The terms "closed" and "open" refer to the external circuit of the machine. Thus, when the machine was "closed," its current was working through the normal external resistance—that of the sixteen lamps. When "open," no current was generated.

These results agree very well with those obtained by other engineers with other machines of the same size and style. On February 6, 1879, Mr. Noah R. Harlow, of the Lowell Water Power Co., measured the power absorbed by one of these sixteen light machines located in the Merrimac Print Works, Lowell, Mass. The speed of the machine averaged about 747 revolutions per minute while operating sixteen normal lights, and the total power absorbed under these circumstances was found to be 13·86 horse-power, including friction of dynamometer employed.

On March 18, 1879, another machine was measured at the dry goods depot of John Wanamaker, Philadelphia, Pa., by Wm. Lee Church, of the Buckeye Engine Co., of New York. Mr. Church employed the method of indicator diagrams, and obtained as a result 14·5 horse-power for the total power absorbed by the machine when operating sixteen lights. The speed of the machine was not given in his report, but was presumably about 750 revolutions per minute, as he was aware that this was the speed at which the machine should be run.

The higher results obtained by Mr. Holmes may be attributed to the increased speed at which his machine was driven, and the abnormal friction at the journal bearings, due to their newness.

Referring to the electrical measurements already described, we find that we have a current of 10·04 webers, with a total resistance of 83·51 ohms. Now, the value in foot pounds of any current is $C^2Rt \times 0{\cdot}737335$; wherein C is the current in webers, R the total resistance of the circuit in ohms, t the time in seconds, and 0·737335 the equivalent in foot pounds of one weber per ohm per second. Hence, the value in foot pounds per minute of the current from the sixteen light machine is: $10{\cdot}04^2 \times 83{\cdot}51 \times 60 \times 0{\cdot}737335 = 372410{\cdot}58$. This, divided by 33,000 = 11·285, which is the energy of the current expressed in horse power. Again,

$$\frac{11{\cdot}285}{15{\cdot}48} = 0{\cdot}729;$$

hence, 72·9 per cent. of the total power applied at the pulley of the machine was converted into current. We have already found that 84 per cent. of the entire energy of the current appeared in the voltaic arcs. Multiplying 72·9 by 0·84, we have 61·24 as the percentage of the total driving power appearing in the arcs.

If we deduct friction and resistance of air from the gross power absorbed, and consider only the power actually absorbed in the production of current, as is usually done in determining the efficiency of dynamo-electric machines, we have

$$\frac{11{\cdot}285}{13{\cdot}78} = 0{\cdot}8189;$$

or 81·89 per cent. of the absorbed power converted into current. As before, 84 per cent. of this current appearing in the arcs, we have $81{\cdot}89 \times 0{\cdot}84 = 68{\cdot}79$ per cent. of the entire power absorbed in the production of current, present as heat and light in the sixteen arcs.

RECAPITULATION.

Resistance of dynamo-electric machine.....	10·55 ohms.
" " external circuit	72·96 "
Total resistance of circuit.	83·51 "
Resistance of 16 voltaic arcs.....	70·86 "
Percentage of current available for external work	87·36 "
Percentage of current appearing as heat and light in 16 voltaic arcs.....	84·00 "
Electro-motive force of current	839·02 volts.
Volume of current.....	10·04 webers.
Total driving power required	15·48 H. P.
Driving power absorbed in production of current	13·78 "
Energy of current expressed in horse-power,	11·285 "
Percentage of gross power converted into current.....	72·90 "
Percentage of absorbed power converted into current.....	81·89 "
Percentage of gross power appearing in arcs,	61·24 "
Percentage of absorbed power appearing in arcs.....	68·79 "

These results require no comment. Their excellence is apparent. They have not yet been approached by those of any other dynamo-electric apparatus operating multiple lights; or even by those operating single lights.

Mr. Louis Schwendler, in his excellent "Report on the Results obtained by the *Electric Light Experiments*," dated London, Nov. 1, 1878, gives the percentage of absorbed power appearing in the electric lamp, in the cases of four dynamo-electric machines. The lowest result given was 30, and the highest 62 per cent., the latter with a machine of the Siemens type. This is much the highest efficiency we have yet seen reported authentically of any dynamo-electric machine. The result was obtained only under the most favorable circumstances, as pointed out by Mr. Schwendler, viz.: with a machine furnishing a single light, and developing a large volume of current (29·5 webers) of comparatively low electro-motive force.

The Brush machine, developing a much smaller volume of current, of a vastly greater electro-motive force, and operating sixteen lights, yet shows a much higher efficiency, viz. 68·79 per cent.

From the peculiar nature of the Brush system of lighting, arise very important advantages over other systems, not yet touched upon. We refer to the great ease with which the lights may be operated a long distance from the dynamo-electric machine, and the small loss of effect occasioned by so doing.

When a separate dynamo-electric machine is employed for each light, according to the systems which appear to be most in favor in England and France, or when the same machine furnishes several currents, each operating a light, then each lamp must be independently connected with the machine, and the whole loss of current occasioned by the resistance of the pair of conducting wires must fall upon each single lamp. There must also be as many complete sets of conductors as there are lamps.

In the Brush system, one pair of conductors is sufficient for all the lamps, no matter what their number may be; and the loss due to these conductors falls not on each lamp, but is equally divided between all. Hence, in order to reduce the loss in each light due to the conductors in the single light system to the same amount as that in each light in the multiple light system, the size of the conductors in the former case must be to that of the conductors in the latter case, directly as the number of lights operated in the multiple light system to unity. And, since the single light system requires as many sets of conductors as there are lamps, while the multiple light system requires but one set of conductors, the total weight of conductors required for a given number of lamps (keeping the total loss of effect due to this cause the same in both systems) is as one, for the multiple light system to the square of the number of lamps for the single light system. To illustrate: Suppose sixteen lights are operated at a given distance from the dynamo-electric machine or machines, and the loss of current due to resistance of conductors is limited to a certain amount, and let the weight of conductors required in the multiple light system be represented by 1, then the weight of conductors required in the single light system will be $16^2 = 256$. Hence, in operating a large number of lights at a long distance from the source of power by the single light system, either an enormously expensive system of conductors must be employed, or else a great part of the whole energy of the currents will be wasted in overcoming the resistance of the smaller conductors.

This objection to the single light system is fatal when any considerable separation of the machines and lamps becomes necessary.

The Brush system of lighting being free from this defect, the lights may be maintained at a great distance from the source of power with very little loss of effect, and by means of conductors of moderate size and cost. The resistance of number 10 (Stubs gauge) copper wire of commercial purity, is about 0·6 ohm per thousand feet; therefore 7,600 feet of such a conductor will equal in resistance only one of the sixteen lamps already described:

$$\frac{4{\cdot}56}{0{\cdot}6} \times 1{,}000 = 7{,}600,$$

so that fifteen lamps of full power could be operated through such a conductor of this length; or the whole sixteen with a loss of only about 6 per cent. in effect. Only 50 per cent. of the total effect would be sacrificed by working through such a conductor more than eleven miles in length (60,800 feet), and this loss might be reduced one-half by doubling the size of the conductor, which would still be of moderate dimensions.

No reference has yet been made to the use of more than sixteen lamps in the circuit of the No. 7 machine; but 17 or 18 lamps are often employed with the machine running at its normal speed of 750 revolutions per minute, and with good effect, although the total light produced is less than with sixteen lamps. At the speed at which the above described measurements were made, viz., 770 revolutions, nineteen or twenty lamps may be burned with tolerably good effect, although the maximum amount of light is obtained with sixteen.

As many as thirty-three lamps have been operated simultaneously in the circuit of a No. 7 machine running at a speed of 800 revolutions per minute, with an arc of appreciable length in each lamp, but the total light produced was less than half that obtained when sixteen or seventeen lamps were employed. When the number of lamps operated by the No. 7 machine, running at full speed, is reduced below sixteen, the brilliancy of the remaining lights is of course increased, but not in proportion to the reduction in number. Hence the total amount of light is diminished. The *quantity* and *intensity* of the current are such as to produce the maximum light in sixteen arcs.

At the time Mr. Holmes measured the power required to drive the sixteen-light machine, he also measured that required by a six-light machine of the size and style known as "No. 5."

This machine furnished six beautiful lights in single circuit, similar to those of the No. 7 machine, but with somewhat shorter arcs. (It will be remembered that the No. 7 machine was driven above its normal rate of speed.) The total power required to drive this machine was 4·5 horse power. The following are Mr. Holmes's figures:

Total power developed with the 6-light machine at 922 revolutions "closed".....	7·18 H. P.
Less friction load of engine "light"...	2·44 "
" " due to increase of load (7·18—2·44—4·74) at 5 per cent....	0·24 "
Total power required by 6-light machine....	4·50 "

No measurements of the current from this machine were made.

REMARKS.

Much has been written by eminent electricians and others about the enormous loss of total lighting effect which follows the use of more than one center of light in an electric circuit. Some state that the total light diminishes as the square of the number of lights increases; others that the loss is as the cube of the number of lights.

These extraordinary assertions are made without any reference to the energy or character of the current employed, and are never supported by any experimental data.

The experience of the writer has uniformly shown that when a small amount of electrical energy is expended at several points, very little or no light results; while if the same energy be properly expended at one point, a large amount of light may be evolved. On the other hand, when a *large* amount of current energy is properly expended at a number of points not too great, the total light produced may nearly equal that evolved when the whole energy is concentrated at one point.

A certain amount of energy is required before any light at all is produced, and if the division falls below this point, nothing in the way of light results. But after a certain point is reached, at which a good light is produced, then the increase of light appears to be almost directly as the increase of energy exhibited in the arc, the length of the latter remaining constant. Mr. Schwendler's experience here appears to coincide with our own. In his report, before mentioned, he says: "If we make the highly probable supposition that the resistance of an arc of constant length is inversely proportional to the current which passes through, then the light produced would be proportional to the current. This appears to be the case." Again he says: "Although the light must be very nearly proportional to the total energy consumed in the arc, the resistance of the arc decreasing with the increase of the current, it follows that the light *can not* be proportional to the square of the current."

It is argued by many that an increase of energy in the arc produces a corresponding increase of temperature in the carbons, and that, according to a well-known law, the light must increase much faster than the temperature. But, in fact, after a certain point is reached, the temperature of the positive or light-giving carbon does *not* increase with increase of current, but the area of surface heated to maximum increases almost directly with the current. The "certain point" several times alluded to, is at that stage of the process when vaporization takes place over a well-defined spot on the positive carbon. Obviously, when rapid evaporation has commenced, the temperature of the carbon cannot be increased at that point, and an increase in the amount of heat evolved can only result in an increase in the rapidity of vaporization, or vaporization over an increased area.

A careful study of the voltaic arc, and of the carbon points after being used with currents of various strength, cannot fail to convince the most skeptical of the truth of these assertions.

Quite contradictory to the spirit of those portions of Mr Schwendler's report, already quoted, he says in another place: "If more than one light is produced in the same circuit by the same current, the external or available light becomes rapidly dearer with increase of the number of lights produced. For this reason already, if not for many others, the *division of light* must result in an engineering failure."

It seems scarcely possible that Mr. Schwendler could have overlooked the obvious fact that a current representing a given amount of energy, and adapted to produce the maximum light from one center, may, by having its dimensions suitably altered, *i. e.*, its electromotive force increased and its volume diminished, while its energy remains the same, be adapted to produce its maximum light from several small centers, instead of from one large one (provided, of course, the energy of each center is not reduced below the "certain point" before defined). Yet he seems to have overlooked or entirely ignored this fact.

The performance of the No. 7 Brush machine with its sixteen lamps, already detailed, proves unquestionably that the division of a large current energy among many lights in the same circuit, or, more properly, the *multiplication* of lights on a single circuit, has resulted in a great engineering *success*.

The votaries of the single light system would advocate, in place of the No. 7 Brush machine, the use of *sixteen* small machines, with their costly system of conductors. *Each* of these would require as much attendance and involve as much expense for repairs as the single large machine. At least fifty per cent., and probably one hundred per cent., more driving power would be required to produce sixteen lights of the same size, and the first cost of the apparatus would be vastly greater. Further, if the lights were required at any considerable distance from the source of power the single-light system must prove *entirely* impracticable.

Since writing the above, a larger machine than the sixteen-light machine herein described has been completed and thoroughly tested. It gives forty lights in a single circuit, each light having the same length of arc and using the same volume of current as the sixteen-light machine. The electromotive force of this machine is about 2,300 volts, and the volume of the current 10 webers. The horse power required is 36, and the relative economy of this machine, as compared with the sixteen-light machine, is somewhat increased. A large number of these machines have already been ordered by manufacturing establishments and for lighting stations in cities and towns.

M. WIEDEMANN'S ELECTRIC PAPER.

ORDINARY letter paper, if well heated and briskly rubbed with the hand or with a brush, acquires electric properties; it adheres to tables, walls, etc., and on contact with the hand it gives slight electric discharges, visible in the dark. But on taking Swedish filter paper, and submitting it to the treatment described below, its electric properties are greatly intensified, and sparks may be drawn from it several centimeters in length. The paper is steeped in a mixture of equal volumes of nitric and sulphuric acid, as in the manufacture of gun cotton. The paper thus pyroxylized is washed with abundance of water and dried. If laid on a sheet of waxed paper and rubbed briskly it manifests energetic action, and may be used for the repetition of almost all experiments in static electricity.—*Comptes Rendus.*

A COSTLY LETTER ENVELOPE.—Among the curious articles in the Indian Court of the Melbourne Exhibition are two hollow elephant tusks fitted with a gold cover. They were sent to the Viceroy of India by the Rajah of Burmah, who used them as an envelope for an official communication. They are valued at $1,000.

THE TELEPHONIC SYSTEMS OF DR. CORNELIUS HERZ.

BY COUNT DU MONCEL.

Notwithstanding the progress accomplished in telephony since the origin of this invention, it had hitherto been impossible to obtain a clear and strong transmission of speech when the distances were somewhat large. This fact is proved by the discontent of many subscribers of telephonic exchanges, who often pretended that they were absolutely unable to hear anything with their telephones. It is true that this fault of hearing sometimes results from a constitution of the ear that is not well adapted for telephonic sounds, and especially from a bad education of the organ of hearing for that kind of correspondence. But we must also acknowledge that there exist many other causes which prevent the sounds that are produced by the telephones from being sonorous and clear, especially when these sounds have to be transmitted over a telegraphic line which is always influenced by accidental currents of all kinds, such as earth currents, induction currents, atmospheric currents, etc. In order to counteract these currents upon somewhat long lines, it is necessary that the undulatory currents that are transmitted have a certain amount of energy, and it was necessary, therefore, to employ telephones with which a battery was used. But on account of the fact that the variations of resistance depending upon the transmitting apparatus which furnishes the undulatory currents are relatively feeble in comparison to the resistance of the entire line, the inflections of the electric waves are not distinct enough to generate all those little sinuosities that correspond to articulate sound. These inflections become more or less effaced by the resistance of the line, and are partially suppressed by the accidental electrical currents which pass over them. In order to avoid this inconvenience it was necessary to solve two problems: (1) The amplitude of the electrical vibrations had to be greatly increased, without this increase of amplitude having to be required from the voice; and (2) electrical currents foreign to those transmitted had to be prevented from passing over the telephonic circuit. These two problems have been solved by Dr. Herz in his telephonic systems, of which we give to-day a complete description.

Several means may be used to obtain an increase in the strength of electrical waves: (1) The so-called derivation system. (2) Microphonic systems which offer a great number of contacts formed by bodies which are semi-conductors, but which are at the same time so arranged that the resistance is not too great. (3) When undulatory induction currents are used, the amplitude of the electric waves may be increased by augmenting the duration of these currents themselves. All of these means have been utilized and patented by Dr. Herz, and the good results that have been obtained are already known.

The second part of the problem has been solved by the same method which is employed in submarine cables, viz., by an interruption of the circuit itself, either by placing condensers or apparatus that are able to diffuse the electric charges, such as lightning arresters (Cardes) into the circuit. The problem was directly solved by introducing as receiver a speaking condenser in the circuit. When ordinary telephones were used the introduction of "cardes" or condensers between the apparatus and the earth were sufficient. It is easily understood that the interruption of the circuit prevents accidental currents from being propagated, or if they are propagated—which may be the case when telephonic transmissions are obtained by means of open circuits—it prevents them from producing effects that are energetic enough to injure telephonic transmissions.

We will now speak of the arrangements that are employed in the system of Dr. Herz (Fig. 1).

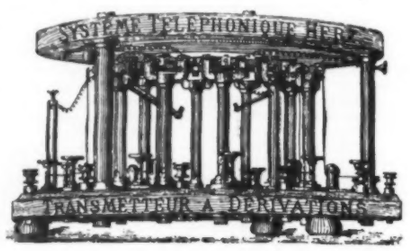


FIG. 1.

In the first system that was used in the experiments made last fall between Brest and Penzance, the transmitter was employed, the front view of which is represented in Fig 1 and the ground plan in Fig. 2, while the electrical details are represented in Fig. 3.

In order to illustrate the principle of the apparatus, however, we must refer to Fig. 4, which gives a general view of the complete system, and is, as may be seen, intercalated at a derivation of the battery. On the other side the battery is the line with its different accessories. Each of its contact points is composed of a plate of carbon or of a plate of pyrite of iron, which are in contact either with pyrites of iron mounted upon balancing levers, the pressure of which is regulated by springs. These levers are placed upon metallic columns as shown in Fig. 1, and in order to better illustrate the arrangement, two of the contacts are shown in our Fig. 1 with lowered levers.

Six plates, consisting of semi-conductors, are arranged around the center of a vibrating disk, which forms the upper part of the apparatus (Figs. 2 and 3), and which serves as the diaphragm to be moved by the voice.

Each of the pyrite plates communicates with the contact-points of the elements of the battery, as seen in Figs. 3 and 4, in such a manner that the current generated in each element traverses each contact point.

The battery consists, therefore, of twelve elements, which are all united in tension.

In order that all contact points may form an uninterrupted chain from one end to the other, and in order that they may be also used separately, the points of the contact-lever are united by means of a conducting wire, consisting of two branches, which extend from one plate to the other, as seen in Figs. 3 and 4.

When we follow the course of the currents for some time, we see that the current of the first element at the left of the battery goes directly to the earth, passing the first contact at the left of plate No. 1.

The current of the second element goes also to the earth, passing the second contact of plate No. 1, and afterward the first contact. The current of the third element passes the first contact at the left of plate No. 2, the first contact at the left of this plate, the branch-wire of the second contact of the first plate, the two contact points of this plate, and finally goes to the earth; the same is the case with all the remaining elements of the battery, which, being united in tension, are all in correspondence with the opposite side, *i. e.*, with the right hand side of the line.

As the first element at the left of the battery is, besides, in connection with the earth, so the currents of all the single elements of the battery have two ways upon which they may pass, viz., the circuit consisting of the contact-points of the transmitter, and the circuit formed by the line. This arrangement has been made in order to diminish to a great extent the resistance of the twelve contact points of the transmitter, which is very considerable, in order to intercalate them at a derivation to the earth, and finally, in order to amplify the variations of resistance in the transmitter. Thus the amplification of the variations is obtained in a double manner: first, by the effects resulting from the derivation; secondly, by

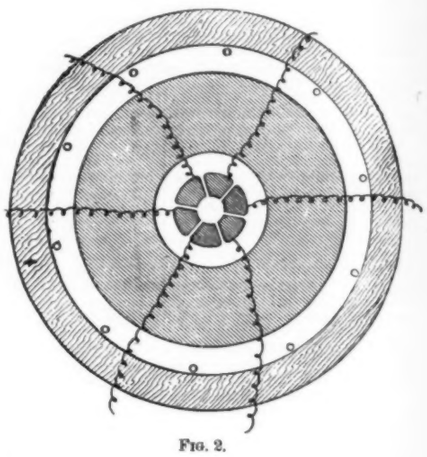


FIG. 2.

those resulting from the increase of the number of contact points, and by the fact that derivations are established at each element of the battery, the total resistance of the transmitter is greatly diminished.

A little calculation will be very useful, in order to get a correct idea of the importance which results from the use of the derivation system under such conditions. Let us call δ the circuit of the line; d, the derivation circuit, consisting of the contact points of the transmitter; E, the electromotor force of the battery; and r, its resistance. According to Ohm's formulas, when the transmitter, having the resistance of a, is directly introduced into the circuit, the value of the intensity, I, may be found by the following formula:

$$I = \frac{E}{r + a + \delta}$$

and in a case where the transmitter forms the derivation, the value will be shown in the formula:

$$I^1 = \frac{E}{r + \frac{r\delta}{a} + \delta}$$

This formula only differs from the former by the intermediary quantity between r and δ, which is a in the first, and $\frac{r\delta}{a}$ in the second case. It can easily be seen from these two

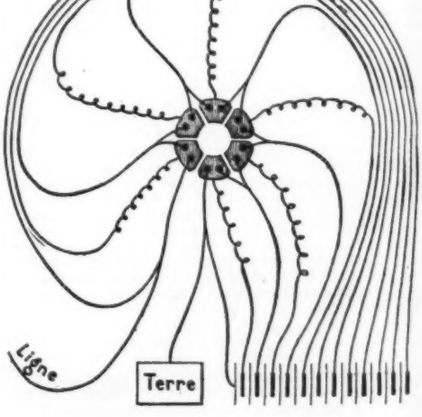
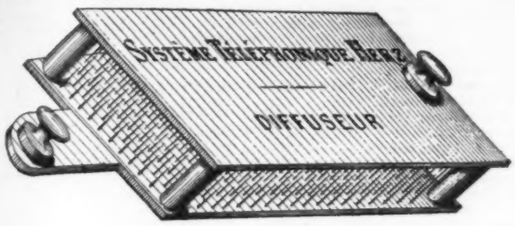


FIG. 3.

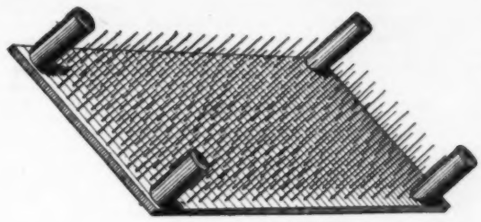
mathematical expressions that the variations of a must change the value of I in one case much more than in the other. Let us, for example, suppose that $r=5$ ohms, $a=10$ ohms, and $\delta=100$ ohms. The total resistance forming the divisor of E will be, in case of the use of a simple circuit, $5+10+100=115$ ohms, and, in case a derivation system is employed, we will have

$$5 + \frac{100 \times 5}{10} + 100 = 155$$

Now, let us suppose that in consequence of a change of pressure at the contact-points, a is reduced to two ohms, the resistance in the first case will then be equal to 118



THE DIFFUSER.



ONE HALF OF DIFFUSER.

ohms, while in the second case it will reach 168 ohms. In consequence of the variation of intensity, the telephonic circuit will in the first case be influenced in the proportion of 1 to 1.017, while in the second case the proportion will be 1 to 1.064. From these data it will be understood how much the sensitiveness is increased by the use of the derivation system.

In the first experiments which were made with this transmitter between Brest and Penzance, all kinds of magnetic telephones were used as a receiver, and the experiments were made both with and without condenser, and with or

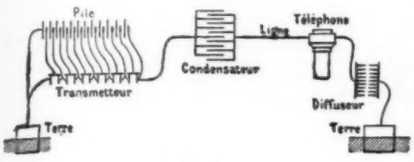


FIG. 4

without the diffuser (carde) seen in Fig. 4. The results, already at that time, were so satisfactory that a practical solution of the question could be expected within a short time, and the entire press gave their opinion to that effect.

As regards practicability, the disposition shown in Fig. 1 offers some inconveniences. A certain delicate regulation of the contact-levers had to be employed, and as soon as telephonic systems need a regulation, their practical value cannot be considered very great. It was necessary, therefore, to avoid this inconvenience, and a success was obtained in a very simple manner by using the apparatus shown in a ver-

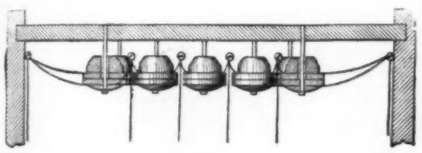


FIG. 5.

tical section in Fig. 5, and in a plan in Fig. 6. In this apparatus the contact points are also formed by pyrites or other metallic sulphurets, and are suspended in pairs by means of rods from a thin wooden plate, which serves as a vibrating plate.

Under these conditions the contact surfaces are large enough to diminish the resistance of the apparatus, and to guarantee, besides, a good contact, little round plates of lead touch each couple of disks, as shown in Fig. 5.

The other electrical connections are established as shown in Fig. 6, and are the same as those of the first system; only

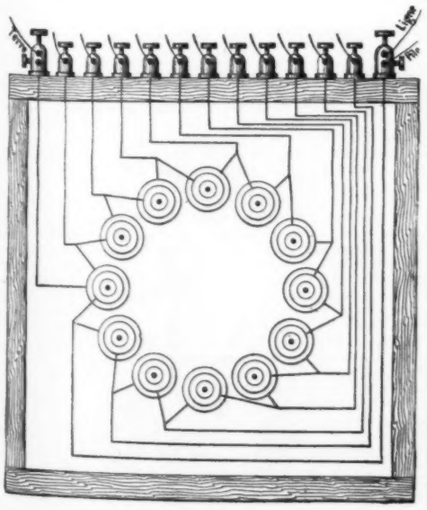


FIG. 6.

that the number of the contact couples in the new system is twelve, instead of being six, for the plates with double contact have been abolished, the connections of the double-branched wires extending from the upper to the lower disk. Experiments, however, have shown that the system may be simplified by using only three couples of contact points.

With an apparatus of this construction the conclusive experiments between Orleans, Blois Tours, Poitiers, Angouleme, and Bordeaux, which have furnished the important results of which we have spoken already, have been made for three months past. In these experiments numerous researches have been made, in order to ascertain which is the best manner for connecting the battery with the contact points of the transmitter.

As receivers, the magnetic telephone, and also the *speaking condenser*, have been employed, and it might be interesting to give an account of the experiments that have been made with this latter instrument for about a year.

About the 23d of June, 1880, Mr. Herz invited me to witness the experiments which he made at Boulevard Saint-Marcel, and drew my attention to the fact that a condenser of small dimensions, such as are constructed by the manu-

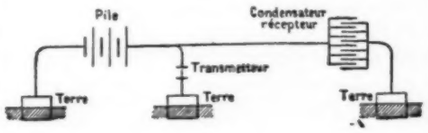


FIG. 7.

facturers of Paris, would, under certain conditions, reproduce speech. I saw at once *that by intercalating the transmitter by derivation of the current, the condenser which was used as receiver contained always a potential electricity equal to that of the battery, and that the action of the transmitter had only the effect of diminishing more or less this potential electricity in the moment of its action; consequently all variations of resistance produced by the undulatory waves were thoroughly reproduced by the condenser.*

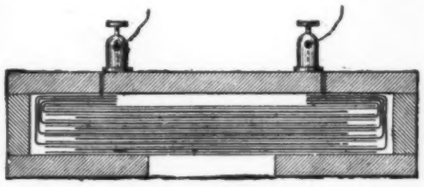


FIG. 8.

Fig. 7, which is taken from the patent obtained by Dr Herz on the 9th of June, shows plainly the arrangement of the system.

From the time that I witnessed the above named experiments, numerous experiments have been made with the speaking condenser, in order to ascertain the most advantageous disposition of the battery for the loud reproduction of speech by this apparatus, and some time elapsed before it was found. But since the trials made over the line between

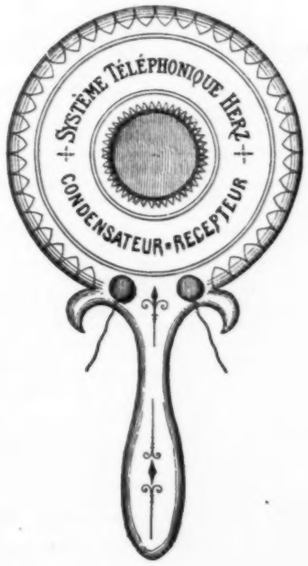


FIG. 9.

Orleans and Bordeaux, important improvements have been made in the use of this condenser in regard to electrical combinations. Finally, perfect success has been obtained with this apparatus on lines which offer enormous difficulties for telephonic transmissions. But this success was due to the use of a new transmitter, which we are unable at present to describe, and the electrical combinations of which are particularly adapted to the properties of induction currents. The value of this invention is the greater for the fact, as we have said in the beginning, that it presents the extreme advantage of preventing the disturbing effects of abnormal currents that pass over the telegraphic lines. We represent the receiver in a vertical section in Fig. 8, while Fig. 9 shows the exterior aspect of one of the numerous forms that have been given to it.

During the experiments of which we have spoken, condensers having an electro-static capacity of from 5 to 10 microfarads and more, were interposed in the line, but the results were not as great as was at first believed, on account of the fact that these condensers greatly diminished the intensity of the transmitted current. Nevertheless, these experiments gave some idea of the great role that these condensers may play as a means for avoiding accidental and abnormal currents.

With the new transmitters, of which we are not yet permitted to speak, it was possible to considerably reduce the number of the elements of the battery, and the derivations that had to be employed for the apparatus shown in Fig. 1 could be abolished; the amplification of the electrical waves was obtained in a different manner. With this system it was possible to hear speech, as we have already stated, at the enormous distance of 1,100 km. = 660 miles, but it was necessary to make the experiment during the silence of the night, for instance, at three o'clock in the morning. It was discovered that by using three Leclanché elements, it was easy to send telephonic messages over the lines between Paris, Tours, Poitiers, etc., even when the neighboring lines were in full activity.

The transmitter with multiple contacts was also successfully used without derivations of the battery and by uniting all contacts with each other, but it was necessary to interpose them at the derivation branched to the earth. A strong battery, however, consisting of 32 elements had to be used, and 64 elements did not give superior results. It was ascertained, besides, that the sounds were not as distinct as those produced by the above-described arrangement.

The speaking-condenser was employed with perfect success between Paris and Orleans and between Paris and Tours. Finally in Paris itself remarkable experiments have been recently made, which have shown that the use of this condenser presents great advantages for telephonic offices. Of this matter and the results obtained we will speak in another article.

The above are, in short, the experiments that have been made for three months past by Dr Herz upon the different telegraph lines of France. They are, as it may be seen, very remarkable, and seem to definitely solve the telephonic transmissions over large distances. We regret not to be able to give a description of the last system, which is the most complete and the most practical of all, but we will do so as soon as the rights of the inventor are secured in the different countries.

ON RADIOPHONY.

By E. MERCADIER.

THE author gives the name radiophony to the phenomenon lately observed by M. G. Bell, in which a radiation rendered intermittent according to a given period produces, on falling upon bodies cut in plates, a sound of the same period. He finds that radiophony does not appear to be an effect produced by the mass of the recipient plate vibrating transversely in its totality like an ordinary vibrating plate. The nature of the molecules of the recipient and their mode of aggregation do not seem to exert a predominating influence upon the nature of the sounds produced. The radiophonic sounds result from the direct action of the radiations upon the recipients, and principally a surface action. The effects are relatively very intense, and seem to be principally produced by the so-called thermic radiations.

ON AN ACOUSTIC PHENOMENON NOTICED IN A CROOKES TUBE.*

By CHARLES R. CROSS.

A SHORT time since, while experimenting with a Crookes tube, I noticed a phenomenon which was quite striking, and so evident that it hardly seems possible that it has not frequently been observed before; but as no allusion to the effect in question has come to my notice, I venture to call attention to it.

In working with the tube in which a piece of sheet platinum is rendered incandescent by the concentration upon it of electrified particles, repelled from a concave mirror, I noticed that when the mirror was made the negative electrode, so that this concentration took place, a clear and quite musical note issued from the tube. I thought at first that the pitch of the note would coincide with that produced by the circuit breaker used with the coil (which made about one hundred breaks per second), but this did not prove to be the case. In fact, very great changes in the rate of the circuit breaker did not affect the note given by the tube. The effect seemed to be produced by the vibration of the sheet platinum in its own period, under the influence of the molecular impact, which vibration was communicated to the glass walls of the tube by the enamel rod to which the platinum was attached, giving rise to a sound somewhat resembling the pattering of rain against a window pane, but higher in pitch and more musical. This sound changed its character very greatly when the direction of the current was reversed, a feeble murmur only being heard. I obtained a similar musical note, though far less loud, with the "mean free-path tube," best when the middle plate was positive. With a tube containing phosphorescent sulphide of calcium, the note was very dull in its quality and low in pitch, but still

* Read at a meeting of the American Academy of Arts and Sciences, November 10, 1880.

quite perceptible. With this tube, a change in the direction of the current, as might be expected, did not affect the sound produced. I did not obtain this musical note from any tube that I have in which the current enters and leaves by a straight wire, except in the case of a single Geissler's tube exhausted so as to give stratifications, in which it was very feebly heard.

RONCALLI'S MELOGRAPH.

WE borrow from our French contemporary, *La Nature*, the accompanying illustration and the following description of Roncalli's melograph, an apparatus designed for automatically and instantaneously inscribing, in conventional characters which may be subsequently easily read and transcribed, all the melodies that may occur to the mind of the musician at the very moment of inspiration.

The first electrical music-registering apparatus that we have to mention was invented and constructed in 1856 by M. du Moncel. This, after some experiments with it, was finally abandoned, perhaps a little too prematurely. Mr. Roncalli's apparatus, like that of M. du Moncel, is based on the chemical reactions produced by currents of electricity, thus in a certain measure reducing the importance of the purely mechanical portion of the register. It is well known that on drawing the point of a steel needle, through which a current of electricity is passing, over the surface of paper saturated with a solution of yellow cyanide of potassium and nitrate of ammonium, there is formed in the paper, wherever the steel point touches it, a salt of protoxide of iron, which appears perfectly black. The color of the tracing made by the point varies with the nature of the latter. Thus, for instance, copper and all its alloys produce red markings; cobalt, brown markings; bismuth, invisible markings, which become of a canary-yellow in a water-bath; nickel and chrome give tracings that are green; while silver produces characters which, at first invisible, become brown under the influence of light.

M. Roncalli's melograph is based on these properties. It is composed of a comb with metallic fixed teeth, which are set very close together, and are traversed by a current from a pile. Each of these teeth is connected by a conducting wire with a key of the piano or harmonium. The teeth corresponding with the natural tones are of steel, and those corresponding with the half-tones are of brass. A strip of prepared paper, moved forward by clock work, passes at a uniform rate of speed under the teeth and receives the tracings made by the teeth, whose corresponding keys are being struck. The length of the marks inscribed on the paper are proportional to the duration of the corresponding sound, that is, to the value of the note. Fig. 1 gives a general view of the apparatus as arranged in connection with a parlor organ; and Fig. 2 shows the details of the registering mechanism, which, in Fig. 1, is seen to the right. The box to the left incloses the clock-work movement which unrolls the paper, and the pyramidal-shaped one in the center is a metronome, the operation of which will presently be noticed. The registering mechanism (Fig. 2) consists of a metallic cylinder, A, which is connected with the zinc pole of a pile that is sufficiently powerful to effect the decomposition of nitrate of ammonium. At B is a comb which is movable around an axis, C, and which is composed of 41 teeth, each of which communicates, by means of an insulated wire, E, with a binding-screw, D, from whence proceeds a second insulated wire, G, which is connected with each of the keys of the piano. The small lever, N, permits of the teeth being brought against or removed from the cylinder at will. The paper is carried along by the two cylinders, F and L, between which it passes. The cylinder, F, is actuated by clock work (Fig. 1), through the aid of pulleys and a small cord. Upon its surface there are nine grooves, which receive an equal number of toothed circles, which are pressed against the cylinder by means of a spring. Upon the drum, M, is rolled the supply of prepared paper which is to pass between the cylinder, A, and the comb, B, and between the two cylinders, F and L.

From one end of the key board to the other there extends beneath the keys a brass ribbon which is connected with the positive pole of the battery. Small springs placed under each key set up a communication between the ribbon and the metallic pieces in which terminate the conductors, G, that are connected with the corresponding binding-screws, D, of the receiver. The operation of the apparatus may now be readily conceived. Upon striking one or more notes the current passes into the corresponding teeth of the comb and inscribes upon the unrolling paper a series of marks whose position indicates the height, length, and duration of the tone. For a natural tone the line is black; for a sharp or flat it is red.

A five-octave organ would require the use of a comb having 61 teeth, and as the latter are only one-twenty-fifth of an inch apart, the width would be about five inches. To diminish such a width of the paper strip, M. Roncalli overlines the two extreme octaves, the first being inscribed over the second, and the fifth over the fourth; these being distinguished by a vertical brown line traced above or below by cobalt. By this arrangement there are required but 39 teeth and a strip of paper three and a quarter inches in width. In order to indicate the time of the music M. Roncalli introduces into the comb two extra teeth made of an alloy of bismuth and copper, affording an orange colored character on the paper. As the apparatus was first arranged, the musician sent the current to these teeth by working the pedals, and thus marked two orange-colored points at the beginning of each measure; but this operation proved annoying to the performer, and the inventor therefore substituted a metronome, the action of which is automatic and perfect, provided the musician submits to the time marked for him by this instrument. In practice, however, this is fully as inconvenient as the former plan—and perhaps more so—since in the same piece of music different measures succeed each other quite often, and the performer cannot, at the very moment of his inspiration, stop to change the movement of the metronome so as to adapt it to the new rhythm of the melody. The fact is that registration of the measure, or, more exactly speaking, the *separation* of the measures, is a problem which does not appear to have been fully solved in any of the systems as yet known. In other respects, M. Roncalli's apparatus is perhaps the most practical one that has been devised up to the present time.

THE MICROSCOPE AND THE ATOMIC THEORY.

AT a recent meeting of the Elmira (N. Y.) Microscopical Society, Dr. Ford read a paper upon "The Relation of the Microscope to the Atomic Theory of Matter," in which he speculated upon the query, "Can we hope that the microscope will show us an atom or a molecule?" He defined an atom and molecule, and spoke of the highest magnifying power that had been attained in the best objective that had yet been produced. He referred to Huxley's statement of three years ago, in which he said that if objective makers could not produce lenses that would show spaces between lines 1-100,000th of an inch apart, a molecule would never be seen. But in 1880 Helmholtz has seen Nobert's lines ruled 112,000 to the inch, and yet the molecule remains unseen. He spoke of Prof. Rogers's theory, that the probable limit of the eye's capability of seeing is about one 4,0 0,000th of an inch. He commented upon the wonderful rulings upon glass made by Nobert and Mr. Fasoldt, the latter having ruled lines, by means of a delicate machine, that numbered ten millions to the inch. The maker, of course, had never seen the lines he had ruled, but he knew they were there, because his machine had made them, and were only waiting for some objective to reveal them. His band of 90,000 to the inch had been seen by many microscopists. The striæ upon the *Amphipleura pellucida*, numbering 132,000 to the inch, are now plainly resolved by the best objectives of wide angular aperture. This is the best that has so far been accomplished, leaving the resolution of the molecule a thing to be accomplished in the distant future.

He next dwelt upon an easy method of determining the amplifying power of an objective, by means of the *camera lucida* and the micrometer slide. Gave examples of the relative magnifying power of the highest objective.

Liebig says of the atomic theory that "the chemist merely maintains the firm foundations of his science when he declares the existence of physical atoms and molecules as an incontrovertible truth," although, like the ruler of Fasoldt's lines, he has never seen them, but just *knows* they are there. Prof. Helmholtz has determined, approximately, the diameter of a single molecule of water, which he estimates at one 250,000,000th of an inch. The professor then described Helmholtz's method of measurement by means of a soap-bubble and the wave lengths of light.

He next commented upon the construction of our present lenses, and of the microscope of the future, with possible diamond and sapphire lenses, possessing greater refractive power, but leaving his attentive audience to infer that an atom and molecule would probably never be revealed, notwithstanding the great improvements likely to be developed in microscopic objectives.

PHYSICAL SOCIETY, LONDON, JAN. 22, 1881.

PROF. W. G. ADAMS in the Chair.

"*Notes on the Construction of the Photophone*," by Prof. Sylvanus Thompson, were read by Prof. Reinold. Prof. Thompson was led by experiment to question whether Prof. Bell's form of photophone receiver was adapted to give the best results. Theoretically he finds with a given maximum of incident light distributed uniformly over the surface, the change of resistance in a selenium receiver will vary proportionally with its linear dimensions, provided its parts be arranged so that on whatever scale constructed the normal resistance shall remain the same. A cell n times greater linearly each way will produce n times the variation in resistance for the same total amount of light. This follows from Prof. W. G. Adams's law that the change in the resistance of selenium is directly as the square root of the illuminating power. The author also finds that if the thickness of the conducting disks in the enlarged cell be kept the same as before, and their number increased n times, the change of resistance will be n^2 times as great as before. Selenium cells should therefore be as large as possible, and the light should be distributed over them uniformly, not focused to a point. A conical mirror would therefore be better than a parabolic one to receive the beam. Such a reflector would be cheaper to construct, and there would be a minimum of loss by reflection, as the light would fall perpendicularly on a cylindrical cell parallel to its axis. To give the best effect its angular semi-aperture should be 45°, and this will bring the front end of the cell in the same plane as the mouth of the reflector. Prof. Thompson has also constructed an improved cell by winding parallel wires on a cylinder of slate grooved with a double-threaded screw, and filling the interval between them with selenium. This form gives superior effects to Prof. Bell's disk device.

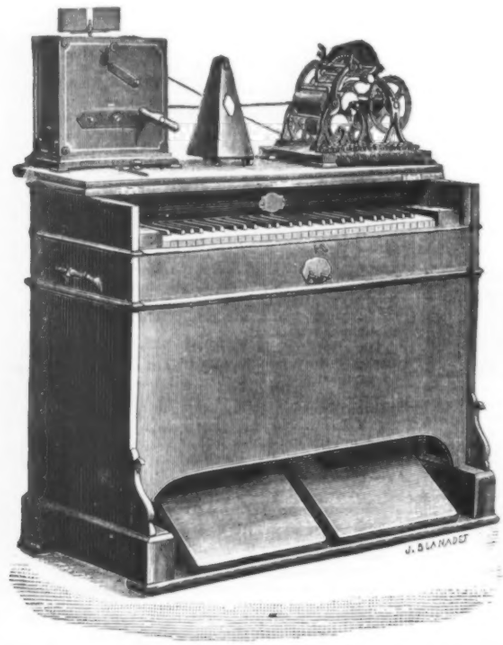


FIG. 1.—MELOGRAPH ARRANGED FOR USE ON A PARLOR ORGAN.

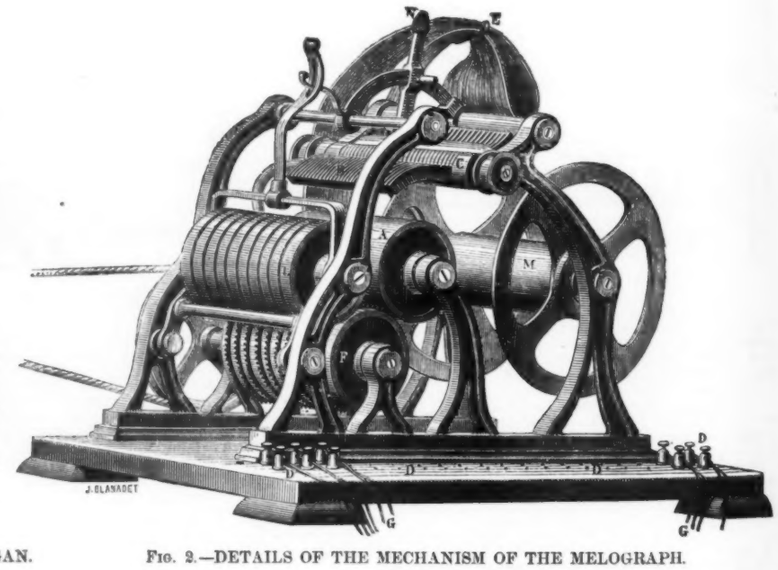


FIG. 2.—DETAILS OF THE MECHANISM OF THE MELOGRAPH.

Mr. Shellford Bidwell said that long annealing improved the sensitiveness of selenium for photophonic purposes. He got the best speech from cells of high total resistance made with fine wire. The selenium should, however, have a low specific resistance. With the apparatus he showed at a recent meeting of the Society he could now transmit articles from *Nature* and the *Nineteenth Century* so as to be heard every word by the listener.

Prof. Guthrie suggested that amorphous phosphorus should be tried in place of selenium, as a more permanent substance.

Mr. Glazebrook, of the Cavendish Laboratory, Cambridge, read a paper on the measurement of small resistances, and the comparison of the capacities of two condensers. In measuring small resistances by the Wheatstone balance, the results differed on varying the resistance in the battery wires. According to Prof. Chrystal this was due to a thermo-electric effect produced by the hand at the middle point of the divided platinum-iridium wire when the contact is made with it. It could be avoided by making this contact first and then making the battery contact. Mr. Glazebrook investigated the effect mathematically and experimentally. He suggested that the resistance in the battery wire should be kept small in comparison with the other resistances, and then the effect was inappreciable. It could also be eliminated by taking two measurements with reversed currents and calculating out. The author next considered the effect of a small leakage in comparing condensers by the Wheatstone balance method. He showed that the method was more sensitive when the resistances of galvanometer and divided coil were large.

Dr. J. Hopkinson stated that he had found a modification of this plan to be very promising. For the battery he uses an induction coil, and for the galvanometer a telephone. Thus a high electromotive force and sensibility was obtained.

THE BANISHMENT OF BEES.—At the petition of the Parisian refiners of beet root sugar, the Prefect of the Seine has proscribed bees in the neighborhood of the city. A single refiner in the 13th arrondissement estimates his losses at 25,000 francs.

THE OUTRIDGE ENGINE.

THE Outridge box-engine is so called because all the working parts except the eccentric and valve rod are contained within the cylinder. This engine has been materially improved, and its capabilities further developed by its manufacturer, Mr. A P. Postlethwaite, 11 Queen Victoria Street, London.

We now illustrate the engine thus improved and applied to a steam launch which was built and engined by Mr. Postlethwaite. This launch is illustrated in elevation at Fig. 1 and in plan on Fig. 2 of our engravings. She has been running on the Thames for the past eighteen months, and is still running, her owner being in every way satisfied with the results achieved. She is 35 feet long by 5 feet 9 inches beam, and 3 feet 9 inches deep, and has a mean speed of thirteen miles an hour. She is carvel-built, of pitch pine, with teak cabin 9 feet long, fitted with lockers, benches, etc. There is a deck over the boiler, another deck aft, and a cuddy-deck forward fitted with lockers and seats The engine has a cylinder 6½ inches diameter, with a 3½ inch stroke. It is of the vertical type, fitted with slide valves, feed pump, reversing gear, etc. The boiler is of steel, multi-

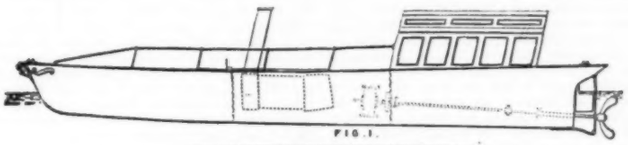


FIG. 1.

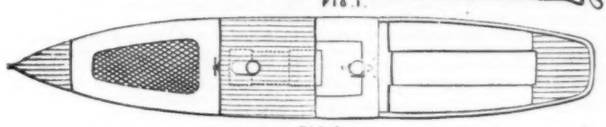


FIG. 2.

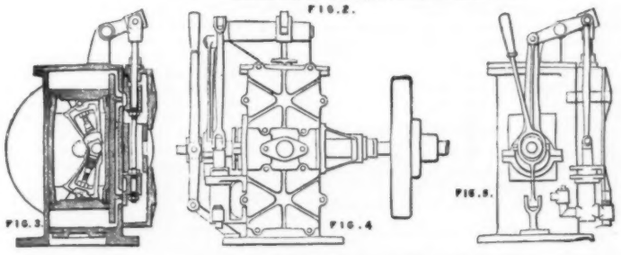


FIG. 3. FIG. 4 FIG. 5.

THE OUTRIDGE ENGINE.

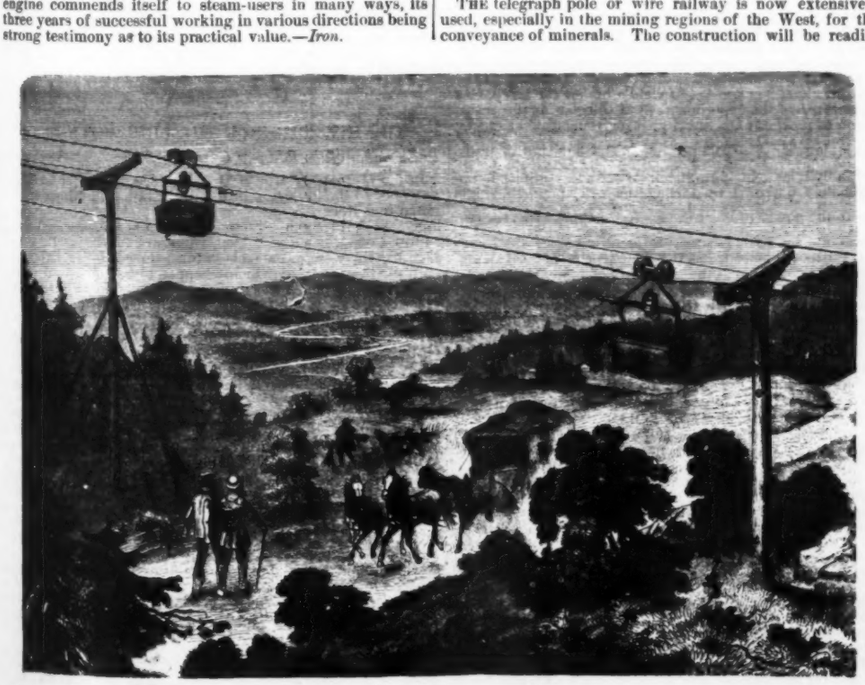
tubular brass tubes, and of the locomotive type. By comparing the engine, as illustrated in Figs. 3, 4, and 5 of our engravings, with the horizontal double cylinder engine, illustrated in our previous notice already referred to, the detail improvements will be observed. These consist, first, in the substitution of broad cast-iron rings, in place of three Ramsbottom rings, at either end of the piston. Then there is a new method of supporting the sectors by means of slots and slide blocks, in place of the bridle rods. This improvement reduces the slip of the sector on the piston plate to a minimum. In this engine there are now, moreover, two slide valves (for purposes of economy in steam) in place of vibrating circular valves. Slide valves are used in this engine for driving launches, as in this type they have certain advantages, and are the better known form of valve. We would also direct attention to the method of driving the pump by using the same eccentric as that actuating the valves; also to the method of reversing by an arrangement of self-locking sleeve-gear. This is very handy, simple, efficacious for instantly reversing, and dispenses with an eccentric. The reported consumption of coal is from 4 to 4½ lb. of coal per i. h. p. per hour. On the whole, the Outridge engine commends itself to steam-users in many ways, its three years of successful working in various directions being strong testimony as to its practical value.—*Iron.*

IMPROVEMENTS IN GAS ENGINES.

MR. WILLIAM FOULIS, C.E., of the Glasgow Corporation Gas Works, has made some improvements in gas engines, having reference to the better and more economical working of this class of machine. Mr. Foulis's object is, first, to construct the cylinders and pistons of gas engines in such a way as to separate the part of the cylinders wherein the explosion takes place from that in which the piston works. Mr. Foulis proposes to make his cylinder in two parts of about equal length, to be fixed, in the case of a vertical engine, one over the other, and separated by a thick packing of millboard or asbestos. The hottest half of the cylinder may be lined with asbestos or other non-conducting material, and the side of the piston which is presented toward this part of the cylinder is similarly covered. This side of the piston also carries a tubular piece of nearly the same diameter as the inside of the cylinder, and nearly as long as either part of it. This tubular piece is separated from the working piston by the non conducting coating above mentioned, and is itself protected in the same way. The combustion end of the cylinder is coated outside with non-conducting material, and the working end is cooled by a water jacket in the usual way. It is hoped by this method of construction to keep the combustion chamber hot without heating to a commensurate extent the working cylinder. Means are also provided to prevent the perfect combustion of the gaseous mixture from which the power is drawn being interfered with by the foul gas remaining in the combustion end of the cylinder. To effect this the mixture is to be contained in a separate combustion chamber, inclosed or appended to the cylinder; and into this chamber enters, but without actual contact, a small piston which projects from the center of the driving piston. The combustion of the gaseous mixture is made to take place in this combustion chamber, while the loose piston closes its end and keeps back the foul gases. The proper mixture of air and gas is effected in a separate flexible chamber, which is so arranged as to keep up a supply of the mixture, from which the engine, when in motion, draws off the quantity required. The igniter used is the form patented by Mr. Foulis in 1878, arranged to ignite the mixture after the piston has made a portion of its forward stroke.

THE AERIAL RAILWAY.

THE telegraph pole or wire railway is now extensively used, especially in the mining regions of the West, for the conveyance of minerals. The construction will be readily understood by a glance at the engraving. The basket containing the load is suspended by an iron crane on a pair of grooved wheels that run on a stout wire, supported at the extremities of the post cross arms. The baskets are made to travel by means of the smaller wire, which at each end of the route, or at suitable divisions thereof, passes around driving pulleys that are operated by a suitable motive power.



THE AERIAL RAILWAY.

THE VARIOUS MODES OF TRANSMITTING POWER TO A DISTANCE.*

By ARTHUR ACHARD, of Geneva.

THE author proposes in this paper to furnish a summary of the practical results obtained in the transmission of power to a distance, a subject on which some articles of his have appeared in the *Annales des Mines* between 1874 and 1879. While the interest attaching to this subject is unquestionable, the author is, nevertheless, very doubtful whether a successful result can be attained in one particular application, namely, the establishment of large undertakings for distributing hydraulic power to a number of factories, either existing or contemplated, similar to the undertakings at Schaffhausen, Fribourg, and Bellegarde, which the author has elsewhere described in detail. At the first of these places, in spite of favorable circumstances, rapid extension of working, and good management, the profit has been very small on the capital outlay. The manufactories at the two other places, being much less favorably situated, have failed after a short and profitless existence. Their failure has shown very clearly that their founders labored under a strange delusion in supposing that cheap motive power was in itself sufficient to create industries in localities where their essential elements were wanting. The author accordingly considers there is not much to be gained from this method of transmitting power to a distance, and that it can only succeed financially under exceptionally favorable conditions. He now proceeds to examine the various methods used or proposed for transmitting power to a distance.

I. *Transmission of Power by Wire Ropes.*—Transmission by iron wire ropes is merely an extension of the simple case of transmission by ordinary hemp ropes, and the same principles apply to both. These principles may be briefly stated as follows: Let A and B be the axes of two parallel shafts carrying two pulleys whose planes coincide. The driving power, P, acts on A, and the resistance, Q, on B. For simplicity let it be assumed that these two forces act tangentially at the circumference of the pulleys. The motion is communicated from A to B by means of the rope passing round the two pulleys; of this the part which is passing toward the driving pulley is called the driving span, and the part which is passing from the driving pulley is called the trailing span. Let T be the tension of the driving span, and t that of the trailing span. Neglecting friction, etc., we should have $Q = P$; and the values of the tensions in the two spans are given by the equations $T - t = P$ and $\frac{T}{t} = k$; denoting by k the smallest practicable value of e^{fa} for the two pulleys, where e is the base of Napierian logarithms, f the co-efficient of friction between the pulley and the rope, and a the ratio between the arc encircled by the rope and the radius of the pulley. Accordingly the values of T and t are given by the following equations: $T = \frac{k\,P}{k-1}$; $t = \frac{P}{k-1}$. If the ratio $\frac{T}{t}$ be greater than k, the rope will slip on the driving pulley. The values of T and t, as above calculated, when k has its exact value, are only just sufficient to prevent slipping, which would occur on any accidental diminution of friction. For safety, therefore, it is necessary to assign to k a somewhat lower value than its real one, which practically amounts to increasing the tensions T and t, a little beyond what is requisite in theory. The tension common to the whole rope when at rest is somewhere intermediate between the tensions T and t of its two spans while running; and by adjusting the rope while at rest to this intermediate tension, its two spans assume of their own accord the required tensions T and t, as soon as it begins to run. The section, w, to be given to the rope, so that it may possess the requisite strength, is regulated by the driving tension, T, and must be such that the quotient, $\frac{T}{w}$, shall not exceed the working strain which the material of the rope is suited to bear in practice. It is evident that, in transmitting a given amount of power, the driving tension, and consequently the section of the rope, may be diminished by increasing the speed; for if N denotes the power transmitted, and v the speed of the rope, then $P\,v = N$, and $T = \frac{k\,P}{k-1} = \frac{k}{k-1}\,\frac{N}{v}$. In practice the rope elongates under the continuous pull, and requires shortening from time to time to keep the tension up to the proper amount. We will now take into account the useless resistances, hitherto neglected for the sake of simplicity. The useful resistance, Q, is now necessarily less than the driving power, P, and the ratio $\frac{Q}{P}$ represents the efficiency of the transmission. The useless resistances are two in number. The first is the rigidity or stiffness, due to the imperfect flexibility of the rope. This effect, however, is insignificant in the case of rope transmission, on account of the large size of the pulleys employed. The other useless resistance is the friction of the two shafts, A and B, in their bearings, which is measured by the resultant, F, of all the external forces acting on each shaft. It appears from the principles enunciated above that the employment of rope transmission renders this friction considerable. In fact, under average conditions of adhesion, the value to be allowed for $k = e^{fa}$ is not more than 2; and since in the limit $\frac{T}{t} = k$, and $T = \frac{k\,P}{k-1}$, we have as the least possible values $T = 2\,P$, and $t = P$. These tensions are parallel to each other, and as the useful resistance, Q, may also act in the same direction, the total pressure, F, on the shaft may $= T + t + P = 4\,P$, as a minimum, where the conditions are the most unfavorable; while under the most favorable conditions, the pressure on the bearings will be given by $F = T + t - P = 2\,P$, as a minimum. Hence the average pressure may be taken as at least 3 P. It is evident, therefore, that rope transmission renders the shaft friction much greater than does transmission by toothed wheels. But the effect of this friction is much reduced by the large diameter of the pulleys in comparison with that of their shafts, in consequence of which the pressure on the shaft bearings has to be multiplied by a number not exceeding at most 0·003, in order to obtain the resulting tension on the rope.

The introduction of iron wire ropes for transmitting

* A paper lately read before the Institution of Mechanical Engineers.

power to a distance has arisen from the necessity of replacing leather or gutta-percha by some material less expensive, less affected by atmospheric influences, less extensible, and especially possessing a much higher tensile strength. The large amount of the power which must exist to make special machinery advantageous for transmitting it to a distance does not constitute one of the reasons for the change of material, inasmuch as belts of leather and gutta percha are capable of transmitting very considerable power. In reality they owe this capability to a special property which they possess; and which releases them completely from the theoretical laws to which attention has just been directed in the case of ropes. If the belt is wide, a partial vacuum is produced between the belt and the rim of the pulley, by the aid of an adequate velocity, which causes the atmospheric pressure to press the belt close against the pulley. An adhesion is thereby produced which is totally independent of friction, and enables the tensions to be considerably reduced. Accordingly the tension, T, of the driving span, instead of attaining the value, 2 P, need only equal P. A great reduction of the friction on the bearings is thereby effected, and there is a greater power of transmission with the same section. Thus, while formerly in large factories the belts served only to transmit the power from the revolving shafts to the different machines driven by those shafts, they are beginning to be employed to work the machines direct from the prime mover.

The Americans were the first to adopt this course This extended use of belts is regulated by certain practical rules which it may perhaps be useful to point out. It is advisable to make the belts travel at a high speed—4,000, 5,000, and even 6,000 ft. per minute, which leads to the adoption of large diameters for the pulleys. As flexibility is essential, it is preferable not to double the leather, but to rest satisfied with the greatest single thickness, amounting to five-sixteenths or three-eighths inch, and to resort to large widths. As the adhesion does not depend on the friction, the roughness of the surfaces in contact is more injurious than useful, and accordingly, contrary to the old practice, the hair side of the leather is turned to the pulley. Since the even motion of the pulleys is a very important condition, it is advisable to employ, as far as possible, light and perfectly-balanced pulleys, and supports with a wide base and movable bearings. It is for this reason that American pulleys are sold by the piece and not by weight. The widths which the Americans give to belts put up on this principle are such that the circumferential strain, $P = \frac{N}{v}$ is 50 lb. to 67 lb. per inch of width, which represents a strain of 156 lb. to 185 lb. per square inch of section. There was a leather belt at the Philadelphia Exhibition of 1876, which had a width of 5 ft.; but generally they barely exceed 3¼ ft. or 4 ft., and for greater widths several belts are employed, placed side by side. The invention of iron wire ropes for power transmission is due to M. Ch. Ferdinand Hirn, of Colmar, in Alsace. These ropes are composed of a certain number of strands, each having a core of hemp, which are rolled round a central core, also of hemp. They are wound on in the opposite direction to that of the wires in each strand.

The pulleys are of large diameter, which tends to the preservation of the ropes, helps to render the effect of the stiffness insignificant, and diminishes the effect of the friction of the shafts. If the distance is considerable, the transmissions are divided into several relays, with a separate rope for each. The relays are separated by stations. Each station is provided with a horizontal shaft upon which a double-grooved pulley is fixed, which is the driven pulley as regards the relay terminating there, and the driving pulley in reference to the succeeding relay. The stations are usually arranged on masonry pillars, more or less raised according to the configuration of the ground, for it is necessary that the rope should be in no danger of touching the ground. Sometimes the power has to be partially distributed in its course; under these circumstances the shafts at the stations are made use of for the purpose. Frequently also it is necessary to place intermediate pulleys along a relay, which differ from the end pulleys of the relay in serving merely to support the rope. Occasionally a relay has been made 650 ft. long, but usually 420 ft. to 500 ft. is the limit. The weights of the most ordinary sizes of pulleys employed, including their shafts, are on an average as follows:

Diameter.			Weight.			
			Single-groove pulley.		Double-groove pulley.	
Meters.	Ft.	in.	Kilogs.	Lb.	Kilogs.	Lb.
5·50	18	0	2,775	6,232	3,750	8,267
4·50	14	9	2,350	5,180	3,170	6,988
3·75	12	4	1,100	2,425	1,850	4,078
2·13	7	0	362	798	528	1,164

The pulleys have grooves of the shape of a V, rounded off at the bottom, and having there a swallow-tailed notch in which the lagging is fixed. Experience proves that the best lagging is made of pieces of leather, cut from the hide in the form of the notch and placed in it end upward. When this is filled in all round, the pulley is once more placed in the lathe, so as to turn down the bottom of the groove to the section required. This lagging lasts, on an average, three years. It wears out most rapidly on the intermediate pulleys; it has been observed that the rotation of these pulleys is more rapid than the motion of the rope, which occasions slipping. The iron wires of which the rope is made have to bear two distinct molecular strains. The first, designated by s, is the tension in lb. per square inch resulting from the maximum tension, T, necessary to transmit the motion, and its value is accordingly $s = \frac{T}{i\frac{\pi}{4}d^2}$, d being the diameter of the wires, and i their number. The second strain results from the flexure produced by the winding upon the pulley, and may be expressed with sufficient accuracy by $s = E\frac{d}{2R}$; R being the radius of the pulley, and E the modulus of elasticity of iron, 20,000 kilogrammes per square millimeter, or 28,445,000 lb. per square inch. It is clearly necessary that the sum of these strains, $s + z$, should not exceed a certain limit, which is fixed at 18 kilogrammes (25,600 lb., or say 11 tons per square inch). In most of the ropes with which the author is acquainted the values allowed are approximately $s = 10$ kilogrammes (14,220 lb. per square inch), and $z = 8$ kilogrammes (11,380 lb. per square inch). The speed of the ropes may without any inconvenience attain, and even exceed, 20 meters per second (4,000 ft. per minute, or forty-five miles per hour). To preserve the ropes from oxidation and improve their adhesion, they are coated with a heated mixture of grease and resin.

A special machine, invented by M. D. H. Ziegler, engineer at Winterthur, enables the ropes to be subjected to a preliminary squeezing to increase their length; by this means the subsequent elongation from wear and tear is diminished, and the number of shortenings which become necessary is reduced. It is difficult to lay down any general rule as to the duration of the ropes, for this depends upon the conditions under which they work. In practice it must not be assumed that a rope in constant use will last more than a year. In fact, Professor Amsler-Laffon recently wrote to the author on the subject of the ropes at Schaffhausen: "A rope lasts about one year, some a little more, some a little less. But it must be understood that we do not wait till our ropes break, but replace them as soon as we can no longer depend on their strength. They might, therefore, last rather longer, if we chose to run the risk of interruption in our work." Their short life is certainly a defect in this mode of transmitting power.

According to M. Ziegler, who has considerable experience on this subject, horizontal oscillations are very injurious to the duration of the ropes, and they appear to last longer on pulleys with wide grooves than with narrow grooves. The curve in which the rope hangs is a catenary; and it is upon the form of the particular catenary in which it hangs, whether more or less deep, as well as upon its lineal weight, that the tension to which it is subjected depends. By fixing the weight of the rope and its length, the form which its two spans assume in common, when at rest, is determined, and consequently their common tension; which latter must be such as to produce in running the two unequal tensions, T and t, necessary for the transmission of the power. Moreover, the tension in either span is not the same throughout its whole length; it is a minimum at the lowest point of the curve, and goes on increasing toward the two extremities. The calculation of the tension at the lowest point is very complicated, if based upon the true form of the catenary; but by substituting a parabola for the catenary, which is allowable in almost all cases, the calculation becomes very simple. If the two pulleys are on the same level, the lowest point is midway between them, and the tension at this point is $S_0 = \frac{p\,l^2}{8\,h}$, p being the lineal weight of the rope, l its horizontal projection, which is approximately equal to the distance between the centers of the pulleys, and h the deflection in the middle. The catenary possesses the remarkable mechanical property that the difference between the tensions at any two points is equal to the weight of a length of rope corresponding to the difference in level between the two points. The tensions, therefore, at the two ends will be $S_1 = S_0 + ph = \frac{p\,l^2}{8\,h} + ph$. By substituting for S_1 in the above equation the required values of T and t, and solving it with relation to h, the deflections, h_1 and h_2, of the driving and trailing spans will be obtained. The deflection, h_0, common to the two strands at rest, is given by the equation, $h_0 = \sqrt{\frac{1}{2}\cdot h_1^2 + \frac{1}{2}\,h_2^2}$. If, as before, w represents the sectional area of the iron portion of the rope, s, the unit strain which the maximum tension, T, produces on it, we have $w\,s = T = \frac{p\,l^2}{8\,h_1} + ph_1$. Taking the sectional area, w, of the rope in square inches, and its weight, p, in lb. per foot run, the ratio $\frac{w}{p}$ differs little from a mean value of 0·24 (104 in French measures); and, as previously stated, the safe limit of working tension usually assigned for iron wire ropes is $s = 14.220$ lb. per square inch (French measures $s = 10$ kilogrammes). Hence, $\frac{w}{p}\,s = 0{\cdot}24 \times 14{,}220 = 3{,}410$; and we have the approximate equation $\frac{l^2}{8\,h} + h_1 = 3{,}410$ (French measures 1,040), which is useful, as giving a relation between the length, l, and deflection, h_1, for the driving span of rope. In the case of leather $\frac{w}{p} = 2{\cdot}53$ approximately (French measures 1,100); and as it is impossible to give s a higher value than about 355 lb. per square inch (25 kilogrammes), the relation obtained would be $\frac{l^2}{8\,h_1} + h_1 = 900$ (French measures 275), which, with equal deflections, would give much shorter spans. If the working tension, s, were reduced to the American limit of 185 lb. per square inch (13 kilogrammes) for leather belts, the above figure 900 would be reduced to 470, which would further shorten the span nearly one-half. It is, therefore, owing to the great strength which iron ropes possess in proportion to their weight that they admit of long spans, with a smaller number of supports, and consequently smaller loss of power by friction. They may, therefore, be expected to yield a higher efficiency. As a matter of fact the experiments of M. Ziegler on the transmission of power at Oberursel give for the mean efficiency of a single relay $\frac{Q}{P} = 96{\cdot}2$ per cent. The efficiency of transmission by relays, including m intermediate stations is approximately obtained by raising the efficiency of a single relay to the power of $\frac{m+2}{2}$. It often happens that the two pulleys of a single relay are at different levels, in which case neither span of the rope has the same tension at its two extremities; the tension at the upper end of each exceeds that at the lower by the quantity, p H, H being the difference in level between the two extremities, or, which is approximately the same, between the centers of the two pulleys. It is evidently the tension of the driving span at its lower end which must be regulated so as to obtain the proper driving tension, T, for the transmission; so that there is a certain excess of tension at the upper pulley.

When power has to be transmitted to the top of a very steep incline, the establishment of a relay station exactly at the top of the incline is generally avoided; intermediate pulleys are put there in preference, one for each span, the relay itself being prolonged for a certain distance on the level. This is the course which has been adopted for the transmission of power from the two turbines at Bellegarde, where a height of about 115 ft. has to be surmounted. The author would refer to his published treatise for the description of the transmission by ropes at Oberursel, Schaffhausen, Fribourg, and Bellegarde, as it would be impossible to abridge the account sufficiently for the present paper.

11. *Transmission of Compressed Air.*—Hitherto the method of transmission by compressed air has only been used, so far as the author is aware, for boring the headings of mines, and the long tunnels through the Alps. In these cases, as is well known, the work to be done consists in a rapid boring of holes for the purpose of blasting the rock with powder or dynamite. As this kind of work requires a high pressure of air, and almost entirely precludes the employment of expansion, the utilization of the motive force is necessarily defective; but in consequence of the peculiar convenience which compressed air offers for the work, and particularly the improved ventilation which it affords, the advantage of its employment is undoubted, and leaves in the background the question of efficiency. If, however, this method were resorted to for driving through rock soft enough to be excavated directly by the mining tool, it is possible that expansion might be used in the machine working the tool.

In the case of the transmission of power for general industrial purposes, the question of efficiency is usually of great importance. The ultimate efficiency of transmission is the product of three partial efficiencies: (1) That of the air-compressing machine; (2) that of the pipes by which the compressed air is conveyed; and (3) that of the machine which the compressed air works. The efficiency of the prime mover, and that of the tools worked by the compressed air machine, should not be brought into this estimate. The air-compressing machines, generally called compressors, are piston pumps,* having self acting inlet and outlet miter valves, controlled by springs and worked by the air pressure itself.

The essential condition to be fulfilled by an air compressor is that the temperature of the air during compression should, as far as possible, be kept constant—the reason, as is well known, being as follows: Let P be the power expended while fulfilling this condition. If the air were compressed in a cylinder impermeable to heat, the heat resulting from the compression would remain in it, and would raise its temperature and pressure, thus involving the expenditure of a power, P_1, greater than P, for its compression. But after the compression had been effected, the temperature of the compressed air would rapidly fall to the surrounding temperature, and would only represent a store of power, P_2, less than P; thus the powers, $P_1 - P$ and $P - P_2$, making together $P_1 - P_2$, would be lost. Even if the metal barrel of the compressing pump is not absolutely impermeable to heat it is impossible to avoid, not merely important losses of power, but also an amount of heating that is very injurious both to the working and to the durability of the machine.

It is only by the help of water that the rise of temperature can successfully be kept down within moderate limits The Seraing or water-piston compressor was first tried with this object. The great defect of this apparatus is the loss of power resulting from the alternating movement imparted to a large body of water. This loss is approximately proportional to the volume displaced by the piston, raised to the power ⅔, and to the speed raised to the power ⅔. To reduce this loss it would be necessary to divide the required production of compressed air among a great number of compressors, and to make them work slowly by giving them large dimensions. This renders the first cost of erection and the space required comparatively large.

The speed of the compressors, working on this system at Mont Cenis, was limited to eight or ten revolutions per minute, and that of the smaller compressors, which have been used for headings in mines, has been generally limited to fifteen or eighteen revolutions. It was next attempted to employ the water for cooling in a manner which, while efficacious, should not entail the above loss of power, and should admit of a higher speed of working. The object was accomplished by two methods, which can be used separately or together. One consists in making the water circulate through a casing surrounding the pump barrel, and through cavities formed inside the piston and piston rod. The other method, which is still more efficacious, consists in injecting a very fine spray into the pump barrel, whereby the water is brought into direct contact with the air to be cooled. Both these methods, suggested by M. Colladon, have been applied, under his instructions, to the St. Gothard compressors, and have furnished excellent results. These machines have perfectly answered their purpose, and have worked at a speed of sixty to eighty revolutions per minute, producing only a very limited rise in temperature. The efficiency of the St. Gothard compressors has been approximately from seventy-eight to eighty per cent. The author regrets that he is unable to give more precise figures; but M. Colladon, the consulting engineer of the tunnel works, informed him, only a short time ago, that no experiments had been made as to this efficiency; and more particularly that the effective force of the hydraulic motors which work them had never been measured. M. Colladon had, however, the kindness to furnish him with the result of a trial of his system of compressor, made in the workshops of Messrs. Sautter & Lemonnier, of Paris, the makers of the machine. Nevertheless, it is not possible to place implicit reliance on this result, because the effective power of the motor was not determined by experiment.

(To be continued.)

* The impact compressor, combining the functions of a hydraulic motor and a compressor which was employed at the commencement of the driving of the Mont Cenis Tunnel, need not be included in the list. In spite of its apparent simplicity, it was found to be costly, cumbrous, inefficacious, and easily deranged, and was very soon abandoned. It would unquestionably require further improvements to render it applicable even in very special cases.

THE INVENTION OF THE LINK MOTION.

To the Editor of the Railroad Gazette:

In the *Railroad Gazette* of Dec. 31, 1880, is a letter having reference to the invention of the link motion, in which it is stated that Robert Stephenson had said the inventor of the link was formerly a pattern maker in his employ. Your editorial remarks added to that letter are in the main correct, but there are a few facts not mentioned, but connected with the invention, of which I happen to be somewhat conversant, and which I ask for your permission to place on record.

From November, 1844, to June, 1847, I was working in Stephenson's locomotive establishment, Newcastle, chiefly on the link motion, or what was there generally called the "hand gear," where I had many opportunities of learning particulars of the introduction of the link, then only recently adopted. Mr. Williams, the gentleman apprentice mentioned in your remarks, was then working on the pump bench, and Mr. Howe was one of the pattern makers. With the latter I seldom had occasion to speak, but with Mr. Williams I became intimately acquainted, and from himself I learned the particulars of his claim as inventor of the link, the history of which was believed in by every leading man in the shops, and openly spoken of as a credited fact.

The history ran thus: The conception of the link occurred to Mr. Williams in 1842, when he made some rough sketches of his idea, and showed them to Howe, the pattern maker, asking him, as a private business transaction, to make a model of the link. He left the sketches with Howe, and explained to him fully the object of the link, and what he wanted it to accomplish. Mr. Howe undertook the job, and, as it afterward appeared, was not long in making the

model, but instead of showing it to Mr. Williams, he submitted it to Mr. Wm. Hutchinson, the manager of the works, who, seeing the advantages it possessed over the old "gab motion," sent the model to Mr. Stephenson, who at once gave his approval, with orders for its application to an engine.

One day, shortly after this, Mr. Williams was in the drawing office, and noticed a draughtsman busy with the new link motion, when, on making inquiry about it, he at once discovered the treachery that had been played upon him. He immediately went to the manager and claimed that the link was his (Williams') own invention, and explained how it was he had engaged Howe to make the model. Remonstrance, however, had no effect. He then wrote to Mr. Stephenson, who, at that time, too busy himself to look into the matter, referred the whole subject to the manager, who subsequently succeeded in inducing Mr. Stephenson to believe that Howe was the inventor, in substantiation of which Mr. Williams' sketches were submitted to show that although the idea of the link was apparent, it was not practicable. The explanations and suggestions verbally given to Howe by Williams were carefully suppressed, and in this way his claim was disputed.

There is one piece of evidence, however, that stands out prominently in favor of Mr. Williams' claim, and that is the well-known fact that neither Stephenson nor Howe ever got the link patented, although it was understood that considerable efforts were made to do so; but the threatened resistance of Mr. Williams and his friends was sufficient to prevent that course, and the consequent result was that the link motion never was patented, but became general property at once, and was immediately adopted by all locomotive engine builders. The importance of the invention cannot be over-estimated, when we consider that, after a period of thirty-eight years, the link motion is in general use at this time, in all its original and exquisite simplicity, and is the most felicitous piece of mechanism ever applied to the locomotive.

That Mr. Howe made the original model of the link was admitted, but that he was its inventor was denied before its first application. With Mr. Williams' sketches before him, and the instructions given him for making the model, there was very little left for Mr. Howe to work out; but the little he did was undoubtedly well done, and credit to that extent is due to him. The part taken by Mr. Howe in claiming the link, and his acceptance of Mr. Stephenson's twenty guineas for it, made him an unenviable man among his fellow workmen; and, being of a saturnine disposition, when he left us to go to the Clayeross colliery there was no regret at his departure.

The amiable disposition of Mr. Williams made him beloved by all who knew him intimately. He was known to be well conversant with the steam engine, and had just such qualifications and originality of mind that would lead to investigations for the improvement of his profession.

I desire here to disclaim any personal prejudice in writing this letter—which would not have been written had I not seen the letter and remarks alluded to in your paper—but my personal recollections of the parties concerned and the circumstances surrounding the invention of the link, as represented openly at the early date mentioned, has induced me to place on record what I believe to be facts, desiring only that honor be given to him to whom honor is due. I will merely add that Mr. Williams has been dead many years, and up to the last of his life he maintained his claim as inventor of the link motion.

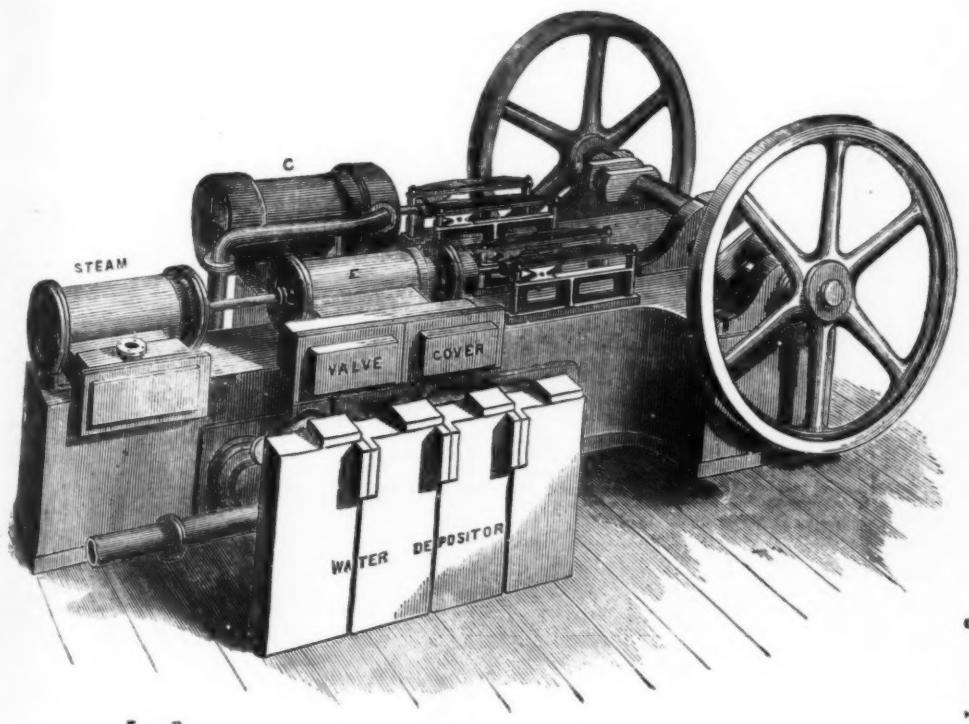
JOHN ORTTON.

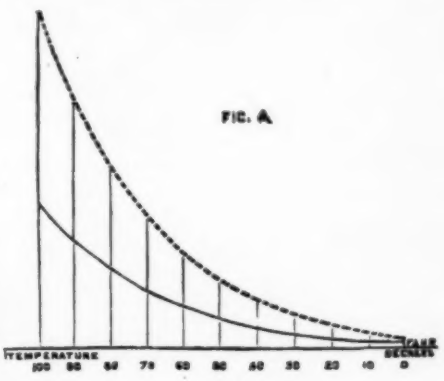
St. Thomas, Ont., Jan. 29, 1881.

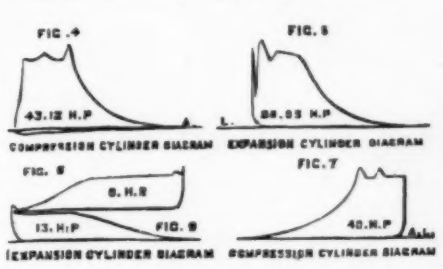
ON MACHINES FOR PRODUCING COLD AIR.

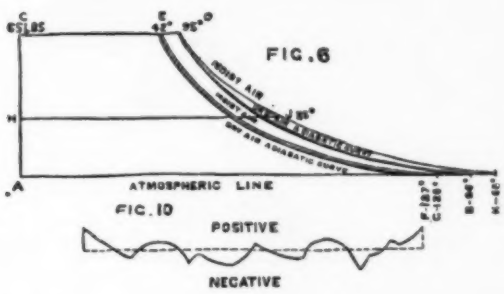
AT the recent meeting of the Institution of Mechanical Engineers, London, an interesting paper was read by Mr. T. B. Lightfoot. We give an engraving from the *Engineer* of one of the machines by him described.

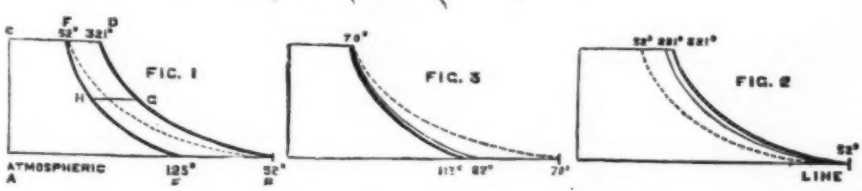
Mr. Lightfoot prepared a great number of wall diagrams to render the construction of the machines he described clear. He began by pointing out that air is rapidly compressed under a piston, without either loss or gain of heat from without, it is raised in temperature, mechanical work expended on the piston being transferred to the air in the form of heat. If this compressed and heated air, at that pressure and temperature, be then introduced below another piston, and expanded without loss or gain of heat from without down to its original pressure, it will also resume its original temperature, and will have given back, while expanding, useful work precisely equal in amount to that absorbed during compression. If, however, after compression, the air is first cooled, by allowing some of its sensible heat to be absorbed by some cooler substance, and then expanded under a piston to atmospheric pressure, a less amount of useful work will be given back than in the first case, and the air, after expansion, will be found to occupy less than its original volume, and to be colder than its original temperature by a difference which is greater or less according as the quantity of heat taken away before expansion is large or small. The operation just described forms the basis upon which the cold air machines treated of in the paper are constructed, and the author proceeded to illustrate the proposition graphically. So much has recently appeared in our own pages on the subject that we need not follow Mr. Lightfoot closely. The diagrams annexed are reduced from those prepared by Mr. Lightfoot to illustrate the theory of his machines, and to a large extent they explain themselves.











IMPROVED MACHINES FOR PRODUCING COLD AIR.

Fig. 1 illustrates the theory of cold air machines graphically. A B represents a volume of atmospheric air—considered for the sake of convenience, as a perfect gas—at a temperature of 52 deg. Fah. This air is rapidly compressed under a piston to the volume, C D. The pressure, A C, above the atmospheric pressure, is then, in the present example, 50 lb. per square inch, and the temperature 321 deg. Fah., giving a rise of 269 deg. Fah.

Now suppose that, instead of immediately expanding the volume, C D, of hot compressed air back to atmospheric pressure, we first abstract a portion of its sensible heat, and so reduce its temperature to 52 deg. Fah., it will be found that its volume will also be reduced to C F, where C F bears the same ratio to C D as the new absolute temperature bears to the old, or C F:C D::513:782. On now expanding the volume, C F, to its original atmospheric pressure, the piston will only be pushed out to the position, E, and the final temperature of the air will be 125 deg. below zero Fah. The efficiency of the operation is represented by

$$\frac{\text{Volume swept through by expansion piston}}{\text{Volume swept through by compression piston}},$$

and the area, B D F E, gives the theoretic mechanical force required for driving the machine. Fig. 2 gives in thick black the adiabatic and in dotted the isothermal curve of compression of a perfect gas, from 14·7 lb. and 52 deg. to 65 lb. per inch. In Fig. 3 the adiabatic and isothermal lines are shown in thick black and dotted lines. The volume, C D, is as in Fig. 2 corrected; the intermediate lines show what is got in practice. In Fig. A the dotted line shows force of aqueous vapor at temperatures from 0 deg. to 100 deg. Fah. The black line shows the weight of aqueous vapor in one pound of saturated mixture of air and vapor at ordinary atmospheric pressure, and at temperatures from 0 deg. to 100 deg. Fah. Figs. 4 and 5 are diagrams from the compression and expansion cylinders of the first machine made by the firm. Fig. 6 is a diagram giving a comparison of the two systems for depositing moisture; one by extra cooling of the wet compressed air by means of the cold expanded air acting through metallic pipes, and the other by utilizing the expansive action of the air itself, on the author's plan. Here C D represents the volume of the air at 95 deg. Fah. and 65 lb. per square inch absolute pressure, as it leaves the first cooler; C E is the volume when it has been cooled at constant pressure to 42 deg. Fah., by the external application of the cold air, during which process heat is given off sufficient to raise the temperature of an equal weight of the dry cold air by 84 deg. Fah.; E F is the adiabatic curve of expansion, and E G the actual curve, allowing for the effect of the moisture still remaining in the air at 42 deg. Fah. The final temperatures for these curves are 127 deg. and 120 deg. below zero Fah. respectively.

On the other system D J is the curve of expansion down to a temperature of 35 deg. Fah.; the pressure is then reduced to 35 lb. per square inch absolute, and the moisture deposited is the same as in the first case, after cooling at constant pressure to 42 deg. Fah. The condensed vapor having been abstracted, and the dried air admitted to the second expansion cylinder, J K is the curve of expansion to atmospheric pressure, while D B is the line of adiabatic expansion from the point, D. The final temperatures are 68 deg. below zero Fah. for J K, and 96 deg. below zero Fah. for D B. Figs. 7, 8, 9 show the first expansion in the new machine, and the final expansion under the piston, the horse powers being calculated at 60 revolutions per minute. The diameters of the compression and expansion pistons are 27 in. and 20 in. respectively, the stroke in each case being 18 in. Fig. 10 is a diagram of crank strains.

An important fact to be noted is that air at constant pressure, having free access to water, will hold a different quantity of water in solution as vapor or steam, at each different temperature; or conversely, the temperature of the "dew point" for any body of air varies with each quantity of water held in solution by it. The hotter the air, the more water can it hold without depositing. Thus if air is highly heated by compression, and water is then admitted to it, in the form of spray or injection, it will take up much more water before becoming saturated than it could have held before it was thus heated. Again, if air under compression and saturated with vapor is allowed to expand, a large quantity of such vapor will condense and freeze into snow, thereby giving up a large quantity of heat to the air, which air is in consequence cooled less than it would have been had it been dry air to start with. This freezing is also a serious practical evil, from the deposition of ice about the valves and in the air passages, which necessitates frequent stoppages even in small machines.

Various means have been devised for ridding the air more or less completely of its contained moisture, by employing some chemical material, such as chloride of calcium or sulphuric acid, which is a powerful absorbent of water. But in the author's opinion the use of such chemicals as are known to him is inadmissible, except perhaps for small machines, or for those working under special conditions, because of the trouble which would be experienced in changing the material, and evaporating off the water it has absorbed, so as to render it again fit for use.

Mr. Lightfoot next proceeded to explain the nature of the isothermal and adiabatic curves, and he compared the theoretical curve with actual curves obtained in practice from machines made by his firm. In one case the initial tempera-

ture of the air entering the cylinder was 52 deg. Fah.; and it contained, as ascertained with a hygrometer, 0·007 lb. of aqueous vapor to the pound of mixture, this being about 88 per cent. of saturation for the observed temperature. By calculation from the volume, the temperature at the end of the stroke was 267 deg. Fah., whereas if the compression had been accomplished adiabatically, it would have been 321 deg. Fah. The air thus compressed is delivered to the cooling apparatus, consisting of an arrangement of small brass tubes, having cold water flowing through them. The air is thus reduced in temperature to within from 5 deg. to 10 deg. of the initial temperature of the cooling water, and with this abstraction of heat, its capacity to retain vapor being lessened, a portion of the moisture it contains is condensed, and may be collected and run off if suitable means be provided. In practice with the machinery under the conditions mentioned above, the air, if cooled to 70 deg. Fah., may be made to part with about one-half of its contained moisture at this stage.

Mr. Lightfoot then noticed shortly some of the machines previously devised for producing cold air. Kirk's machine consists in principle of a single cylinder in which air is compressed at one end and expanded at the other. The heat caused by compression is partially carried off through the cylinder cover, which is water-jacketed, and the cold from expansion is used to abstract heat from a current of brine or other medium, circulating over the cover at the expansion end. Between the two ends is a regenerator, formed of several thicknesses of wire gauze. Through this both the hot compressed air and the cold expanded air pass, on their way from one end of the cylinder to the other; so that there is a continual alternate compression and expansion of the air, and a continual heating and cooling of the regenerator. The Giffard cold air machine consists of one single acting water-jacketed compression cylinder, and one single acting expansion cylinder, both worked from cranks on an overhead shaft. The compressed air is led from the cylinder into the cooler, which is merely a cluster of small tubes placed vertically in a case.

The cooling water passes upward outside the tubes, and thence goes to the compression cylinder jacket; the air is admitted into a casing below the ends of the tubes, passes up through them, and is taken off from the top to a wrought iron reservoir. A pipe from this reservoir supplies the air to the expansion cylinder; the admission and exhaust being controlled by two independent steel miter valves in the cylinder bottom, worked by cams from the shaft. In this machine no attempt is made at drying the air; all the moisture taken into the compression cylinder is discharged in the form of snow from the expansion cylinder, with the exception of the portion deposited in the cooler, owing to the partial cooling of the compressed air. Windhausen's machine expands air from its ordinary atmospheric pressure under a piston; the cooled and expanded air being discharged much below the atmospheric pressure, either through tubes surrounded externally by brine, or into a hermetically sealed chamber, where the objects to be frozen are placed. After this process the air is again compressed to atmospheric pressure, cooled, and re-expanded. The disadvantages of this machine are the large size of the cylinders, etc., necessitated by the very low pressure employed, and the fact of its entirely depending for its action on the production of a partial vacuum.

The Bell-Coleman refrigerator consists of an ordinary machine for producing cold air by compression, cooling, and expansion, combined with an apparatus for depositing a portion of the moisture before the air is admitted to the expansion cylinder. In this system the air is partially cooled during compression by the actual injection of cooling water into the compressor, and by causing the current of compressed air flowing from the pumps to come in contact with a spray of water. From the pumps the mixed air and water is led by pipes into a chamber or chambers with perforated diaphragms, which catch a portion of the suspended moisture. The air, still in its compressed state, and cooled to within 5 or 10 degrees of the initial temperature of the cooling water, is then led to the expansion cylinder through a range of pipes, or other apparatus, with extended metallic surfaces, cooled externally to a lower temperature than that of the cooling water, so as to induce a further reduction in temperature and consequent deposition of moisture. This extra cooling of the compressed air is effected either by allowing the cold expanded air, before it reaches the chamber to be cooled, to come in contact with the range of pipes, or by exposing these pipes to the spent air passing from the cold chamber. The author then considered at considerable length the objections to which the machine was open. It should, however, be stated that he very frankly added that these machines have been successfully worked in cases where a large amount of cooling water of low temperature is available, as, for instance, on board an ordinary Atlantic steamer. There is no doubt that moderately dry air would be obtained wherever a sufficient supply of water at 46° or 50° Fah. can be had.

Sturgeon's refrigerator is a horizontal machine with some novel arrangements as regards the construction of its air-valves and pistons. The compressed air is first cooled partially by being passed through tubes surrounded by cooling water, and then passed through charcoal or some other absorbent of moisture, before being admitted to the expansion cylinder. If the charcoal or other material is properly changed and renewed when necessary, this may form a dry air process; but, as already stated, the introduction of a chemical drier is, in the author's opinion, undesirable, except under special conditions. Messrs. Hick, Hargraves & Co., of Bolton, manufacture cold air machines of horizontal form, in which the Corliss cut-off gear is applied to the admission valves of the expansion cylinder. The air is compressed in a double acting cylinder, into which cooling water is injected at each stroke; it then passes through a series of receivers in which the water mechanically carried over is deposited, and is finally admitted to the expansion cylinder, and expanded in atmospheric pressure. So far as the author knows, no attempt is made at drying the air, which passes to the expansion cylinder fully saturated for its temperature and pressure; but a large snow box, consisting of a series of baffles, abstracts the bulk of the snow from the cooled air, after expansion and before its introduction to the chamber.

In a machine of this description which the author has seen, the snow had to be cleared out from the exhaust valves every few hours. The author then proceeded to describe the cold-air machines manufactured by his firm, which have already been illustrated in our columns, as stated above. Neither of the machines so described were intended to produce dry air, and it is now necessary to explain the dry air process devised by the author. This process depends for its action on the varying vapor capacity of air at different temperatures; but instead of the transfer of heat being accomplished by contact with cold metallic surfaces, involving large apparatus and difficulties from the formation of ice, it is effected by the act of expansion itself. The partially-cooled compressed air, which, when the machine is taking its supply direct from the atmosphere, will always be fully saturated with vapor for its temperature and pressure, is introduced into a small primary expansion cylinder, and there expanded under a piston to such pressure as gives a final temperature of about 35° Fah. The result is the condensation of almost the whole of the contained vapor which is discharged, in the form of mist, with the air, into an apparatus having surfaces so arranged that the mist is deposited on them as water, falls to the bottom, and is drained off. The dried air, still at a high pressure, is then admitted to the second expansion cylinder, expanded down to atmospheric pressure, and discharged cold and free from moisture. As an illustration, assume that compressed air at 95° Fah., and 65 lb. per square inch absolute pressure, fully saturated with vapor, is introduced to the primary expansion cylinder. Each pound of air will then contain 0·008 lb. of vapor. To bring this mixture of air and vapor to a temperature of 35° Fah. will require a ratio of expansion about 1·75, the pressure being reduced thereby to about 35 lb. per square inch absolute. The 0·008 lb. of vapor per lb. of air will now be reduced to 0·0016 lb., owing to the lessened vapor capacity, or lower dew point, of the air; the difference, or 0·0064 lb., being condensed into water, and collected in a suitable receiver. On admitting the dried air to the second expansion cylinder, it will expand to atmospheric pressure in almost exactly an adiabatic curve; and the pound of cooled air, as it is delivered from this second cylinder, will only contain about 0·001 lb. vapor in suspension. The difference between this amount and the 0·0016 lb. admitted from the water collector is discharged as snow, and caught in a snow box. Both these amounts together are, however, so small that the air is practically dry; in fact, on exhausting the cooled air, with this moisture and snow in it, direct from the machine into an atmosphere at 50° Fah., only the slightest trace of mist is visible.

A horizontal dry cold-air machine for marine purposes, one of several now being constructed, is shown in the accompanying engraving. It is intended to supply 5,000 cubic feet of cold air per hour. It has a double acting compression cylinder, with gun-metal liner forming the water jacket, this material being employed in preference to cast iron on account of its greater conductivity. This cylinder discharges the air, compressed to about 65 lb. per square inch absolute, into the series of coolers, made on the same tubular principle as those already described, whence it passes to the expansion cylinder with trunk piston. Each end of this cylinder is fitted with distinct adjustable cut-off valves. The baffles of the depositor consist of a number of grids, placed at an angle—an idea for which the author is indebted to Mr. E. A. Cowper. A jacketed steam cylinder, with adjustable cut-off, supplies the necessary driving power. The disposition of the cylinders in this machine was arrived at and decided upon after very careful consideration of the turning moments about the shaft center, a number of different combinations being taken. For larger machines the arrangement of cylinders would be somewhat modified, depending upon the number of each kind employed, and also upon whether the engine was simple or compound. The author concluded by dealing with the applications of cold air machines.

The discussion which followed was very brief, and of small interest. Although Mr. Lightfoot had freely enough criticised the designs of other inventors, no one defended them or objected to Mr. Lightfoot's statements. Mr. Schonheyder said it was an unfortunate thing that Mr. Lightfoot had used the words "rapidly compressed," because it might mislead. Whether air was compressed slowly or quickly the rise in temperature was the same. He supposed that what Mr. Lightfoot meant to convey was that the compression should be done so quickly that heat could not get time to escape from the cylinder. He then went on to say that he had carried out several experiments with Giffard's cold-air machine, which gave very fair results, the air being cooled by spray; snow was separated with a loss of efficiency, the water giving up its latent heat and keeping the air warm. The temperature of the air as it left the compression cylinder was 131°, while the temperature leaving the expansion cylinder was 8°. There was a tremendous waste of power in working the plunger through the ring of special packing designed by M. Giffard; rather more than one half the power required to compress the air was given back in the expansion cylinder. The machine was not economical, inasmuch as 9 or 10 tons of ice may be made on other systems per ton of coal. He thought that the whole of the heat given out in the compression cylinder should reappear in the water.

JAPANESE IN ENGLISH TYPE.

AMONG other good works of the American missionaries in Japan is an effort to displace the cumbersome Chinese and Japanese letters in writing and printing. With this view the American Bible Society has lately printed, at Yokohama, a new edition of the New Testament in Japanese, the types of which are set in Roman type the same as our English. The work was transliterated by J. C. Hepburn, M.D., LL.D., one of the earliest Protestant missionaries in Japan. It is, says the *Missionary Herald*, the result of the conviction on the part of Dr. Hepburn that there is imperative need of reform in the mode of writing Japanese. This conviction is shared by the great majority of those who have given serious thoughts to the subject.

The great objection to the various systems of writing now in vogue in Japan is the large use which is made of the Chinese ideographic character.

A distinguished scholar once said that the greatest obstacle to civilization in China was the ideographic character, and that same character is certainly the greatest weight the Japanese nation has to carry as it advances toward the civilization of the West.

A printer in Yokohama once informed the writer that he had in stock metal type representing fully 15,000 distinct Chinese characters, but that he seldom undertook a contract of any size which did not necessitate the cutting of three or four new characters per day. This may indicate the immense burden laid upon the student. It is true that a man who has command of seven or eight thousand well selected characters will find reading a comparatively easy matter, yet he will be obliged to resort to the dictionary far more frequently than most English readers would care to do, unless he does as many Japanese readers do, pass on content with a mere guess at the meaning.

There are few among the hard-working classes in Japan who are likely to acquire and keep even the small number of 2,000 characters. To such the literature which the government is encouraging must remain a sealed book. It is safe to say that three-fourths of the adult population of Japan are unable to read the editorials in the better class of newspapers. In the case of the more popular papers the editor places by the side of such ideograph as he considers unfamiliar, explanatory characters representing the sound of the Japanese word for which the ideograph stands. This bungling contrivance diminishes the difficulty of reading, but it gives an unsightly page and increases the size and expense of the book or paper. This is not the most serious objection. The scholars dislike that style of printing, and nearly all valuable books are printed to meet their taste, and thus the lower classes are left with very little that is worth their reading. Even such as they have is so difficult for them to decipher, that it is seldom that a Japanese is found who can read as easily and intelligently as many a boy of eight in America.

Under the present schemes of the government, popular education, in any true sense of the term, cannot be secured.

It is of course difficult to bring about so important a change as is here advocated, but it ought not to be difficult to persuade the Japanese authorities to teach the Roman system in their public schools, along with the present system, and to encourage the preparation of a phonetic literature for the use of those who cannot, or will not, take the time to commit to memory vast numbers of the Chinese characters.

The time spent on the Chinese characters by perhaps half of the school children is largely wasted, because they do not carry their studies far enough to enable them to use freely those they do learn, and hence they are soon forgotten.

If half the time given to the study of these characters could be spent on the Roman letter, reading would become a pleasure to some millions, probably, who otherwise will always regard it a drudgery to be shunned.

The superiority of a phonetic over an ideographic system is so obvious that it hardly needs to be emphasized, and if educators who have charge of Japanese students, or who are in a position to influence the Japanese authorities directly, would only make their influence felt in favor of the introduction of the Roman letter, they could do more than in almost any other way to help on the cause of civilization and true religion.

The text of this edition is the same as that of the standard edition prepared by the Yokohama Translation Committee, of which Dr. Hepburn was a prominent member.

Besides this edition, the American Bible Society has published, or has now in process of publication, four other stereotype editions of the New Testament in Japanese and Chinese types.

THE DISCOVERY OF THE SOURCES OF THE NIGER.

LAST year news arrived in Europe from the coast of Africa which caused considerable sensation. It was reported that two travelers had reached the sources of the Niger, or Djolibah, the great river of Soudan, the course of which was long unknown, and has only been determined in modern times by brave explorers, but the sources have until now remained undiscovered.

The two travelers were MM. Zweifel and Moustier, agents of the house of C. A. Verminck, of Marseilles, who have a factory at Rotombo, in Sierra Leone, not far from Free Town. They publish a curious illustrated narrative of their travels, from which we take the engravings given opposite.

M. Zweifel had long thought of attempting this journey, and was prepared to accept the proposition of M. Verminck to explore the country, with the double object of discovering the sources of the Niger, and of studying the country, with the view of extending the business of their house.

The little expedition embarked at Rotombo on the 8th of February, 1879. It was composed of two travelers, two interpreters, and thirty porters, almost all Congos, charged with transporting the provisions, the merchandise for barter, and the presents designed for the kings, who are very numerous in the states through which these explorers were obliged to pass. They landed in the night at Port Lokkoh, where they were to take the land route, and where the caravan was completed by the addition of thirty new porters. Obtaining permission from the chief Ali Kali to travel through the country of Timne, and a guide to take them over the route as far as Limbah, they started on their march. A guide is an absolute necessity in this country. Without one there is no safety for the traveler.

The caravan advanced slowly, moving in Indian file through the difficult passes, often hindered by the chiefs of the villages, who endeavored to retain them, in order to obtain the greatest number of presents possible in exchange for insignificant gifts.

On the 24th of July they arrived at Big Boumba, the capital of Limbah, a pretty town surrounded by high granite mountains, upon the summit of which, as may be seen in the engraving, there rise, like fortresses, two principal peaks, Kiring and Kakogouda. A beautiful cascade rushes from the side of one of these mountains. Big Boumba is the residence of King Seloki, which signifies wolf. This king, who speaks six languages, or rather six dialects, can neither read nor write. He furnished the travelers with a guide named Linseni, who had previously accompanied Mr. Reade. He was to take them as far as Falaba. They expected to pass through Limbah in eighteen days, the inhabitants of which, as far as Katimbo, are of gentle manners and hospitable, but after departing from Katimbo they found the natives to be veritable men of prey, from whose clutches our travelers had much difficulty in extricating themselves, like all those who pass through this region.

On the other side of Iagalah, the last village of Limbah, where the mountains end, they were cordially received everywhere.

At Songoya they entered the territory of King Sewa, one of the most powerful rulers of the country. Falaba, the capital, is situated twenty-four kilometers farther in a north-easterly direction. This fortified city has often been attacked by the neighboring tribes, the Foulahs, the Kourankos, and the Sangaras, but has never been taken; of this the inhabitants and king are very proud.

MM. Zweifel and Moustier reached Falaba the 16th of August. The next day a great festival was to take place on the occasion of the return of the king's brother, who had recently been made prisoner by the Kourankos, and was to be released by them on that day. King Sewa, surrounded by his dignitaries, awaited the expedition on the veranda of his palace. He gave them a cordial reception, and placed at their disposal his nephew, Filah, charging him to see that they wanted nothing.

Mr. Reade had also arrived at Falaba ten years before, intending to push on as far as the Niger, but he had been prevented from proceeding by the opposition of King Sewa.

The travelers, on inquiring the reason of the opposition of the king, were informed that if Mr. Reade had expressed his intentions from the start, the king would have allowed him

to pass; but he said at first that he had come to see the king, and later that he wished to go to the Niger. He was too late. A second time Mr. Reade was more fortunate, and went not only as far as the Niger, but to Boure. Unfortunately the lack of provisions forced him to beat a retreat.

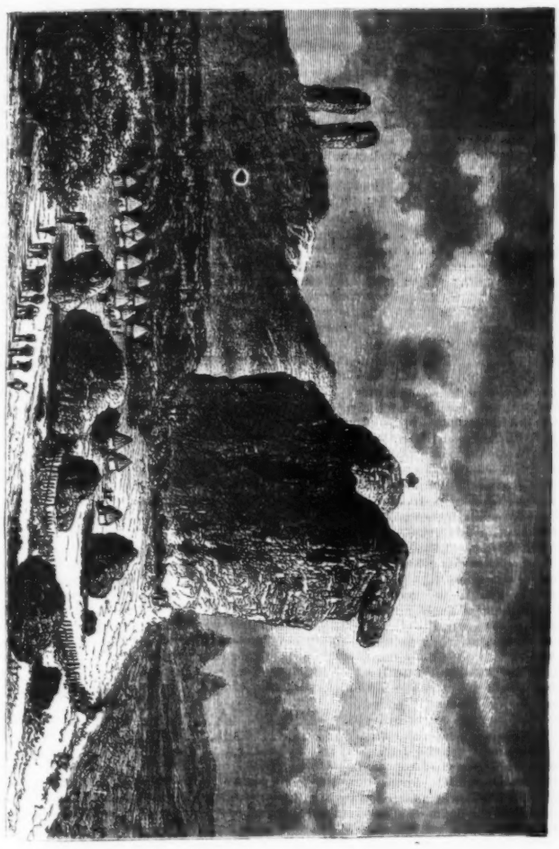
M. Zweifel did not conceal from Filah that his object was to see the source of the "Great River." Filah promised to aid him in accomplishing this object, but recommended him not to speak of his intentions to any one, and to mention it before the king only in his presence.

The next day the travelers had an audience with King Sewa. He received them in the court of his dwelling, which was surrounded by the apartments of his numerous wives, and he gave them the white *kolah*. The *kolah* is a kind of wild chestnut, which produces a tree of great size. This fruit is inclosed in an envelope, which contains fifteen. Some of them are red and some white, and they play a part in the ceremonies of the blacks of the western coast, and have in their eyes different significations. If a white kolah is given to any one, it is a sign of friendship. A red one is the contrary. A lover sends a white *kolah* to the mother of the young lady he seeks in marriage. If a white *kolah* is received in return, all is well; but if the *kolah* is red, he is rejected and must look elsewhere.

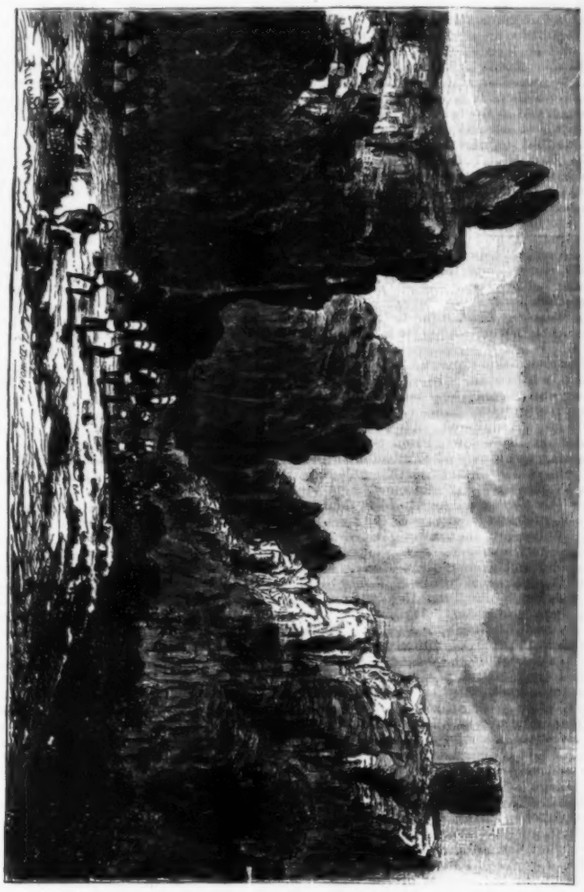
MM. Zweifel and Moustier, having received the white *kolah* from the king, had every reason to congratulate themselves. King Sewa did not cease to give them proofs of his good will. Not only did he do everything in his power to disclose to them the route to the sources of the Niger, but as long as they remained in his capital he used them generously, and treated them with the greatest distinction.

They were with him upon the day of the great festival of which we have spoken, during which King Sewa danced before the Kouranko ambassadors, notwithstanding his age, carrying a heavy load upon his right shoulder—a singular custom obligatory upon them in all their great ceremonies, because the burden thus carried proves the vigor of the King of Falaba, who should always be strong, for when he loses strength, he loses power.

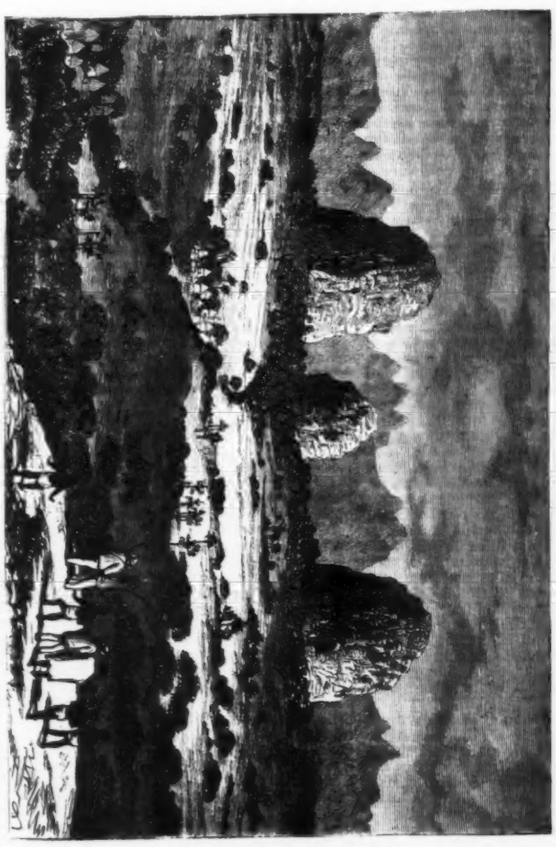
The account of the travels of MM. Zweifel and Moustier is full of interesting sketches. The customs of the natives are studied with care, and their manners perfectly described.



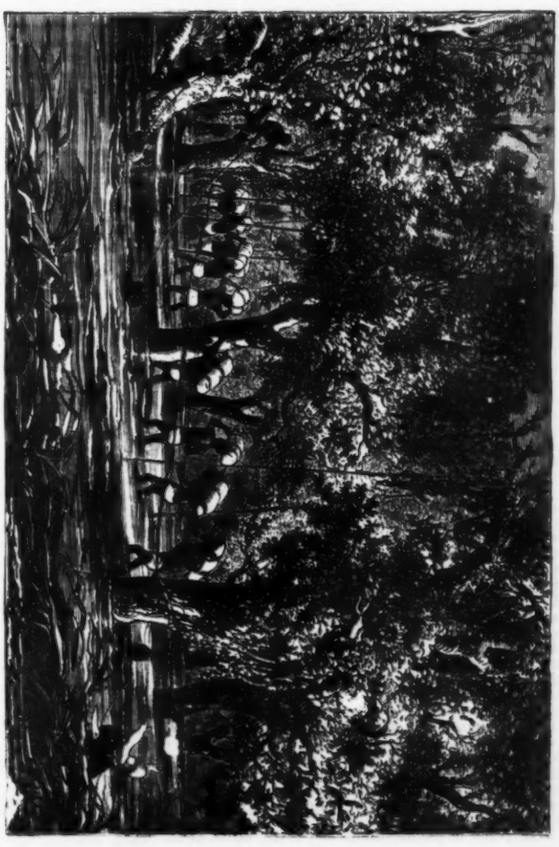
VIEW OF THE VILLAGE OF TANTAFARA AND OF PIC KOULA.



THE EXPEDITION CROSSING THE MOUNTAINS OF BIG BOUMBA.



VIEW OF THE HILLS OF TEMBI COUNDOU, THE PRINCIPAL SOURCE OF THE NIGER.



PASSING THE FALICO UPON A BRIDGE OF LIANES.

THE EXPEDITION OF MM. ZWEIFEL AND MOUSTIER TO THE SOURCES OF THE NIGER.

In reading it one is identified with the travelers, shares their emotions, struggles with them against the deceit, dishonesty, rapacity, and superstitions of the natives—superstitions often carefully preserved by the chiefs, who profit by them.

At Katimbo our travelers saw an old woman suspended to a post by her arms, a heavy stone attached to each foot. She uttered loud cries; suddenly they ceased, and she muttered some words, when they unloosed her to make her repeat them. It was said that she wa a witch, who some days before changed herself into a leopard, in order to eat the heart of a neighboring chief who had in fact been killed by one of these animals, and they were torturing her to make her reveal the names of her accomplices. She had already named some, who had been burned; she named others who were about to meet the same fate, and as she would not be conveyed to the funeral pile until she had ceased to name those whom she called her accomplices, there was reason to believe that in order to prolong her life she would not stop. MM. Zweifel and Moustier remarked this to the chief, but he did not wish to understand them, because custom accorded to the chief a good share of the property of people condemned by the revelations of a witch.

Up to this time the expedition had taken a north-easterly direction. Departing from Falaba, they traveled southward, encountering some opposition and many difficulties. They passed successively through Berria, Tansaya, and Fodaya. A little before arriving at this last village, they met with and passed the Tamincono, one of the three rivers which mingle their waters at Liah, forming the Niger or Djolibah. It is the least important of the three, and its source is near Sangoyah.

The expedition crossed a little farther on the second river, Falico, which springs from Pic Koula. The river had overflown, and the travelers had to enter the water in order to reach the bridge of lianes (a sort of bind-weed) which connects the two shores. After gaining firm ground, they passed on to Socora. From Socora the travelers went to Tantafarra, by way of Sambadongo and Morbaya. From Tantafarra, the city of the King Foreh Wolch, they were able to advance as far as Coulako, but this was all. They were only two hours' march from the famous source of the Tembi, the most important of the rivers which form the Niger. Following the custom, they sent messages to King Demba, to whom the source belongs, informing him of their presence, and asking permission to advance. But neither King Demba nor his brother, Tembi Seli, the high priest of the "sacred source," nor the other priests were willing to give them permission. All that they were able to do, under the pretext of hunting, was to go as far as Foira, where they perceived the river plainly visible between a double row of trees. Concerning the source they were able to collect some facts from a native of Kono. The river springs from the heart of a rock, forms a large rivulet with two branches, which, after passing through a wood, runs into a small lake, in the middle of which is an island. Issuing from the lake, the river passes a village named Tembi Coundon (Head of Tembi), and is directed toward Nella, where it is ingulfed in a subterranean passage. It reappears on the other side of the village, and takes a northerly course.

MM. Zweifel and Moustier remained at Coulako until the 3d of October. Having then lost all hope of disarming the prejudice of King Demba and his brother, in whose eyes they passed as "bad sorcerers," they retraced their steps.

MM. Zweifel and Moustier are not the only explorers who have sought the sources of the Niger. Many others have attempted this difficult task, among them Major Laing, Major Reade, and Anderson. But they were prevented from accomplishing it by the defiance of the population, the almost incessant state of war which reigns between the African tribes, and their superstitions.

MM. Zweifel and Moustier have succeeded in overcoming these obstacles, and have been able at least to determine approximately the location of the sources of the Niger.—*Louis Clodion, in L'Illustration.*

ABNORMAL ENTOZOA IN MAN.*

By Rev. SAMUEL LOCKWOOD, Ph.D.

OUTSIDE or inside, the parasite is everywhere. Nothing that hath life is exempt from invasion by these disturbers of health and happiness. Almost like infinitesimal germs, their eggs course through the air we breathe, swim in the water we drink, enter the ground or settle upon the plants we till, and infest the food we eat. And sometimes these unwelcome guests are insidiously introduced to us by the animals we pet or domesticate. Indeed, the lower animals have a hard time from these tormenting pests. I remember finding Mr. B. Waterhouse Hawkins in his laboratory at Central Park, dissecting a seal which had died in the menagerie there. On opening the stomach, he let off some mild anathemas against the school children, who, he said, had killed the animal. He displayed to us about a pint of pebbles, buttons, slate pencils, and such like *indigesta*, which lay in the animal's stomach. This, to say the least about it, had a very abnormal look. But let us see! Perhaps it was the best the animal could do in the direction of a natural appetency. According to Mr. Elliott, who is authority on the pinnipedes, the fur seals in their own habitats *all* swallow stones, and in every one's stomach, varying in size from that of a walnut, to that of one's fist, a snarl, or ball of nematode entozoa is found. The larger seals, or sea lions, swallow stones which weigh from one to two and even three pounds each; and in one stomach he found ten pounds of these bowlders! Their use, he thinks, is "to grind up these internal pests." It may be that their movements in the stomach sometimes dislodge the parasite when sucking at its walls, thus affording a similar temporary relief to that afforded by a good "scratching" to the victim of *Sarcoptes hominis*.

We may readily distinguish in man the adventitious from the indigenous entozoa. The latter are by scientific consent known as helminths, and the former, although not with strict correctness, have been called pseudelminths, since generally they are grubs, and not worms. Moreover, among the true helminths or entozoan annelids we find more or less of the phenomena of partuenogenesis. Before its life circle is accomplished, it has had several animal hosts, in each of whom it maintained a distinctive form and mode of existence. The grubs, or pseudelminths, are really larvæ of insects, whose changes are known as metamorphoses; and however great these changes may be, the beginning form, the larva or grub, is never wholly lost—for even in the imago state the butterfly is really a winged caterpillar, and the true fly a grub or maggot, with wings.

Cobbold cites, but with evident distrust, the astonishing tables compiled by Rev. J. F. Hope, in which from the Helminthological records of nearly all Europe and Great Britain, he instances not less than forty genera of insects whose larvæ have been entertained in the stomach of man. Strange to say, the greater number are coleoptera, whereas in America I am not able to find one good case of a beetle entozoan; for we are not here considering epizoa, nor those parasites, which from without penetrate the skin; but those only which enter their host by the mucous or alimentary canal. I may be allowed to notice here a very remarkable case, cited by Westwood, the entomologist, and Cobbold, the helminthologist, from Dr. Pickell's account in "Transactions of the Association of Fellows, and Scientists of the King and Queen's College of Physicians in Ireland." A certain Mary Riordan passed, *per anum*, 1,206 larvæ, one pupa, and one imago of the grave-yard beetle, *Blaps mortisaga*. She had, from a superstitious motive, been in the habit of drinking daily water into which she had mingled clay obtained from the graves of two priests. This subject also passed large numbers of the common round worm, *Ascaris lumbricoides*, and the not so common *A. mystax*, indigenous to the stomach of the cat.

I am disposed to believe that quite often the larvæ of the diptera, or flies, occupy the human stomach unknown, the sufferer attributing his distress to some other cause.

Packard cites the Proceedings of the Academy of Natural Sciences of Philadelphia, for 1859, in which Dr. Leidy mentions the case of a physician who submitted to him a number of larvæ which had been vomited by a child. He thought they were the maggots of the blue-bottle fly, *Musca vomitoria*. Another instance was also mentioned. The sufferer in this case was a physician who detected a number of grubs in his discharges, when suffering all the symptoms of severe cholera morbus. These Leidy pronounced as larvæ of a species of Anthomyia, which, it seems, he had already observed in a patient who had suffered in like manner. Murray, in his late hand book, avers his opinion that the cheese mite, flour mite, and milk mite, also the dysentery mite of Linnè, are all one species. This last mite gave the dysentery to Roland, a student of Linnè, who named it *A arus dysenteriæ*. It must be noted here that the mites are, in Packard's classification, degraded, or perhaps, undeveloped diptera, or wingless flies. The urinals of Paris are much frequented by the larvæ of *Teichomyza fusca;* and, disgusting though it may be, the maggots of this fly were evacuated by a woman, who had suffered much from their presence.

But we must come home to some facts which prompted the preparation of this paper. Last July a young man, a teacher, brought me a number of larvæ which, he said, he had passed at stool. His appearance indicated great physical distress. His face looked haggard, his eyes dull and wild. His sight was affected, and his memory impaired. He complained of severe gripes in the bowels, like colic, and occasionally a sense of distress, which he could not describe—a sort of feeling that he was going to choke, as it seemed that "the worms were crawling up his throat." The "worms" in question he had passed the day before; and he thought that in two weeks he had discharged two hundred of them. He said he thought "they kept quieter in his stomach when he ate plenty of meat." He directed my attention to the fact that there were two kinds of "worms," one white, and smooth, and round; and the other flattish, and brown, and hairy. He further informed me that he took his dinner daily to school in a tin-pail. Hence, we see, that he dined on cold food, which was in large part cooked on the previous day. I have the specimens here, and we will look at them with the microscope. It will be seen that they are headless and footless larvæ, they are genuine fly maggots. I have given some study to them, and must pronounce the "round white ones," the grubs of the meat fly, *Sarcophaga carnaria*, whose life history is given in my paper in *American Naturalist*, vol. vii. Unlike the true blow-fly, which lays eggs, our meat fly deposits the grubs already born. These tiny objects insinuate themselves into the creases or folds of the meat, and so for a little while are quite concealed. They take gratefully to cooked meat, and devour it with astonishing voracity. How easily could these be swallowed unperceived by a careless eater, especially if the taint of the meat had not progressed sufficiently to affect the taste and smell!

The brown, hairy, flat grubs belong to the group *Anthomyia*, or flower-flies. It is notable, however, that though the resemblance of some species of these flies to each other is very close, the maggots whence these resembling species come are widely different. Some are round and smooth, others flat and hairy. Hence authors divide this genus, making two, which they call *Anthomyia*, the flower-flies, and *Homalomyia*, the flat-flies. They are bright, gay, diptera, seen in a hot summer day hovering over flowers, and occasionally dipping into their nectar cups. Despite their beauty, however, they are all "bad cattle." They deposit their eggs on the esculent roots of our gardens; also on human ordure; and notably on decaying vegetables. The species before us, I take to be *A. canicularis*. A look at this grub is suggestive of great torment when it becomes an occupant of the human alimentary canal. The smooth, round maggots have spiracles or breathing holes along each side. But as our species revels in the soft animal ordure and the juices of vegetable decay, it is furnished with a strange contrivance—starting from where each spiracle would be is a stout hair with sprangling bipectinations. These are branchial processes. Functionally, they are like the gills of a fish (Walsh); for with these they extract the air from the juices in which they wallow. It has plenty of other single hairs, which are stiff and sharp pointed. Thus constituted, when found where these were, we may regard them as intestinal porcupines.

But how came these unwelcome and really abnormal guests to gain an entrance? It was not unlike that Trojan horse business. My young friend had been eating cold cabbage. The Sarcophaga chose the meat, and the Anthomyia the cabbage—both being, perhaps, in that hot weather a little over-seasoned by time.

The larvæ were brought to me dead and shrunken from being dried up. It is to be regretted that with such ample opportunity none were furnished me alive, so that I might breed the imago. Here I would cite from a note in the *American Naturalist*, June, 1875. Says Mr. Judd: Dr. Martin, of Maysville, Ky., was called to see a boy aged 14, who was seized with violent spasms. A purgative caused the lad to pass at one stool fifty maggots. This was June 5. These were put into moist earth, and on the 17th the perfect flies appeared. They were submitted to Baron Osten Sacken, the dipterologist, who pronounced them *Anthomyia* (Homalomyia) *scalaris*.

Among the helminths is the section *Nematelminths*. This is divided by Packard into two groups, the *Nematodes*, containing *Strongylus*, the round worms, and Ascaris, the pin-worms, both which are normal entozoa, to the human subject. The next group is the *Gordiacea*, which has two genera, *Gordius* the hair snake, vulgarly called, and *Mermis*, the thread worm. These are true helminths. I have never heard of their being guests in the human subject; and yet, as adventitious entozoa, it seems to me they must occur. Their eggs appear to be so disposed of that they find their way into insects, terrestial and aquatic.

The following incident may prove interesting and instructive:

Many years ago I was very successful in breeding the New York stickleback in confinement. My experiments were with the marine two-spined variety, *Gasterosteus noveboracensis*. I tried hard, but in vain, to breed in like manner the fresh water species, the tiny, ten-spined *Pygosteus occidentalis*. At last I got, as I supposed a fine female full of eggs. How I watched her day by day, and saw the abdomen steadily distending, but not the least preparation in the line of providing for an increase of family—for these little fishes are most ingenious nest builders. The affair puzzled me a good deal. At last it died. I opened the tiny thing, and found a hair worm in a hard knot, which, when uncoiled, measured nearly six inches.

Some years ago, Dr. Leidy had submitted to him a white thread worm, which he pronounced a *Mermis*, and, strange to say, it was taken out of the core of an apple which a person was eating. In 1876, a young man sent me a white thread worm, which he had found in the core of an apple which he was eating. Having mislaid the specimen, I speak from memory, and think it was over four inches long. To my surprise, I recognized *Mermis*, and believe it to be *M. albicans*. I learn also that our fellow member, Dr. Williamson, last summer, had a case submitted to him of two of these worms in one apple core, their length each being some three inches, for no measurement was made. These phenomena are extremely puzzling, and must be regarded as very anomalous.

I have here several inches of tape-worm. It is without doubt a *Tænia solium*, as all the characteristic parts are represented. The long, so-called neck, and the head, with not less than fifty joints or proglottides of the so-called body. It was taken from a well prized for its clear cold water. The man was pumping a pail of water for the horse, and observed it in the water. I have made inquiry, and cannot find any way for this to have got into the well. There is, however, a large tree, which overhangs the well, and which is often visited by birds. True, this is not the kind of Tænia indigenous to birds; but as we have shown that non-indigenous entozoa do occasionally occur, it seems to me both possible and probable that a bird dropped it into the well.

I am aware that this subject is, to most minds simply repulsive; but would not a little knowledge of these matters be very wholesome, as it might in many instances save from becoming the unwilling host of very dangerous guests?—*Jour. of Microscopy.*

ON CHICKEN CHOLERA: STUDY OF THE CONDITIONS OF NON-RECIDIVATION AND OF SOME OTHER CHARACTERISTICS OF THIS DISEASE.*

By M. L. PASTEUR.

CONCERNING the properties of the extracts of the artificial cultivation of the germ of chicken cholera, an inquiry presents itself. We have shown that these extracts contain no substances capable of preventing the cultivation of the germs of this disease. They might, however, contain elements adapted to the vaccination of chickens. To investigate this point I have prepared cultivations where volume was not less than 120 c.c. After filtration and evaporation at a low temperature, while infinite care has been taken that its purity should not be affected, this liquid has given a dry extract, which was re-dissolved in 2 c.c. of water, and the totality of this was injected under the skin of a chicken which had never had chicken cholera. A few days afterwards the chicken, after being inoculated with a virus of the greatest virulence, died with the usual symptoms of *unvaccinated* chickens.

This class of experiments led to the following observation, which is of the greatest importance in physiology: When the extract from the cultivation of the germ of this disease, corresponding to an abundant development of the parasite, is injected under the skin of a fresh chicken in perfect health, the following phenomena take place: At first the chicken seems to suffer from a nervous disorder, which is indicated by panting breath and alternately opening and closing its beak; afterward it becomes motionless, assumes the shape of a ball, refuses food, and seems overcome with drowsiness, as is the case with chickens affected with the disease. There is this difference, however, that the chicken wakes up at the least noise. This sleep lasts about four hours, after which the chicken wakes up, looks as well as usual, eats and cackles as if nothing had happened to it.

I have repeated this experiment several times, and have always observed the same facts. Before injecting the extract above mentioned, I took in every case the precaution of injecting an extract of the pure chicken broth, which does not cause analogous phenomena. I have, by this means, acquired the conviction that, during the life of the parasite, a narcotic is formed, and that it is this narcotic which causes the morbid symptom of sleep so characteristic of the disease which we are studying.

By the acts of its nutrition the germ of the disease causes grave disorders and brings on death. The germ, being aërobian, absorbs during its life large quantities of oxygen, and burns up many of the elements of its medium of cultivation. This may be seen by comparing the extract of the broth, before the development of the germ, with the extract of the liquid in which the development has taken place. Everything seems to show that it is from the globules of the blood that the oxygen necessary to its existence is derived by absorption through the tissues. While the chickens are still alive, even when death is still far off, their combs assume a violet tinge at a time when the germ of disease is so little diffused through the blood that it escapes microscopical examination. This species of asphyxia is one of the most curious traits of the disease we are studying. Death is caused by the grave disorders brought about by the development of the parasite in its body, by pericarditis, by serous extravasations, by alterations of its internal organs, by asphyxia, but the sleep characteristic of the disease is caused by a product formed during the life of the germ, which acts on the nervous centers. The independence of these two effects in the symptoms of this disease is further established by the fact that the extract from a filtered cultivation of the germ acts as a narcotic on chickens which have been submitted to the *maximum* degree of vaccination.†

* Read before the New Jersey State Microscopical Society, Nov. 22, 1880.

* Translated from the *Comptes Rendus de l'Academie de Sciences*, of May 3, 1880, by P. Casamajor.

† I should, however, try to isolate the narcotic, and see whether a sufficient quantity could cause death, and whether, in this case, the internal disorders would be the same as those of the disease itself.

These facts will, doubtless, be found worthy of the meditations of pathologists.

Although I have taken already much of its time with this subject, the Academy will allow me to call its attention to some other characteristics of the disease called *chicken cholera*. We know that this disease is rapidly fatal, particularly if caused by a direct inoculation of its germ. It must then appear extraordinary that it sometimes presents itself in the chronic state, as in the case of inoculated chickens; which, after being severely ill, do not die, but seem to get relatively better. They eat, however, very little; they become anæmic, as shown in the discoloration of their combs; they continue to lose flesh, and finally die, after lingering for weeks or months. This fact would not be of primary importance if, at the death of the chicken the germ of the disease was not, in most cases, found in its body, which conclusively proves that the parasite has been present since the last inoculation, always active, although in a mild form, for it brings on death slowly. Doubtless, the germ was placed in some *vaccinated* portion unfavorable to its cultivation. Vaccinated chickens are most apt to present this form of disease, which is of very rare occurrence. We might be led to believe that, in this case, the virulent virus is changed into the attenuated, but this would be an error. In cases of this kind the virulence of the germ of the disease seems, on the contrary, to be aggravated. This may be easily seen by cultivating it artificially, so as to separate it from the blood and inoculating it on fresh chickens.

Facts of this kind help us to understand the possibility of those long incubations of virus, such as that of rabies, for instance, which, after existing a long time in the body in a state which may be called latent, suddenly manifest their presence by the most marked virulence and by death. Do not these facts also throw light on human pathology?

Alas! how often we see virulent diseases, such as scarlatina, measles, typhoid fever, followed by serious disorders of long duration, which are frequently incurable? The facts to which I have called attention are of the same nature, only here we can put our finger on their true cause.

I will conclude by pointing out another peculiarity, which is not less worthy of the attention of the medical profession.

In chickens in perfect health which have been thoroughly vaccinated there often occurs an abscess full of pus on some portion of the body, which does not seem to have any injurious effect on the health of the animal. It is a remarkable circumstance that this abscess is due to the germ of chicken cholera, which remains in it as in a closed vessel, and it cannot propagate, doubtless, because the chicken has been vaccinated. This germ may be withdrawn by artificial cultivation, or it may be directly inoculated on fresh chickens, which it kills in the usual manner after an abundant development. These facts recall the abscesses on guinea-pigs, which I have mentioned in the first communication on this subject, and they furnish a rational explanation of what happens in these abscesses. In all likelihood the muscles of the guinea-pig cultivate the germ more slowly and with greater difficulty than those of chickens; the disease is limited to an abscess, and recovery becomes possible.

I will now conclude this statement, as I have no wish to wear out the patience of this Academy. This subject is, however, so vast and so fruitful that I will ask its permission to bring the subject before it again. I have other observations to present to these. I will add those which will present themselves in the investigations I am now making.

HEREDITARY SYPHILIS.

PROFESSOR ZEISSL contributes the result of a thirty years' experience to the at present much agitated question of the hereditary transmission of syphilis. It is not so much pathological appearances as the ways and means of transmission which are of importance. It is now generally accepted that at the moment of conception syphilis *may* be communicated to the fœtus by the semen of a syphilitic father or the ovum of a syphilitic mother. There is no *must* to this rule, and Zeissl has observed nine cases of healthy children born of parents one of whom had secondary syphilis. As the disease fades in the parents so fades the probability of transmission to the fœtus, though the possibility remains as long as the disease exists, though latent, in either parent; much more so if in both. The fewer and fainter the symptoms in the parents, the less grave are they in the child. Where the disease is latent in the parent the child may appear healthy at birth, and only after three, six, or more months evince the symptoms of hereditary syphilis. Active syphilis in the parents causes abortion, still-births, or early death of the child. Zeissl believes also (1) that the previously healthy mother may be infected by her child of a syphilitic father, though she be not directly infected by him, that is, the man; and (2) that the child of healthy parents may be infected in the womb of, and by, its mother, should she acquire syphilis during her pregnancy. This last, the "infection in utero" of Kassowitz, is proved by a case reported by Zeissl's son, and is accepted by Guibout, Després, Jullien, Bassereau, etc. Not so easy is it to prove that a healthy mother can be infected by her syphilitic fœtus. Still there is one case on record of a mother being infected by nursing her own hereditarily syphilitic child; and Caspari has inoculated syphilitic virus upon various parts of the body of an apparently healthy mother of a syphilitic child without effect. Zeissl does not accept Kassowitz's theory, that, without going through a disease, one can yet be so penetrated and permeated by it as to possess immunity from contracting it: for he almost daily examined for two years previously the healthy wife of a syphilitic husband, and found no primary lesion, yet she during this time bore two hereditarily syphilitic children, who died soon after birth, herself failing in health and losing her hair soon after the first conception, and showing during the second pregnancy a squamous syphiloderm of the palms. In another case he treated a man in 1865, who married in 1867. He examined the wife almost daily. She bore a syphilitic child in 1868, and another in 1869. After the first delivery the wife had general syphilis, but never an initial "sklerose." He has seen also many analogous cases. The fœtus, then, being syphilitic, the mother is almost invariably so also. A woman can also, according to Zeissl, become infected by the semen of a man, with recent but latent syphilis, without being impregnated, and he states that he has seen many such cases. Here the woman shows late forms, like painful periostitis. More frequently, however, the mother is infected by the fœtus through the placental circulation, and may show symptoms belonging to the condylomatous period of the disease, or, as in galloping syphilis, those of the gummatous stage. Such women may subsequently bear healthy children to a healthy man, or even to the same man if he has become healthy.—*Boston Medical and Surgical Journal.*

SHEEP FARMING ON A LARGE SCALE.

THE Washington correspondent of the Chicago *Inter-Ocean* has obtained from Mr. McKellar, the owner of an extensive sheep ranch in Australia, the following information relative to sheep and wool growing in that country:

Australia and New Zealand contain large tracts of undeveloped lands, which may be obtained by persons desiring it in any quantity, even in tracts of 1,000,000 or 2,000,000 acres. The price paid is according to the assumed capacity of the land for production, which price may be fixed by arbitrators, and which continues for fourteen years, when the lease expires. Mr. McKellar said that two cents per annum for each sheep is about an average rate of rental to be paid. After securing his tract, the herdsman sets about fencing it as rapidly as possible, first, however, killing off the wild dogs, which abound in great numbers, and which are much like our coyotes.

THE PLAN PURSUED

for getting rid of the dogs is to broil a leg of mutton lightly, and start a man out on horseback to drag it over the ground for miles around the tract. As the horseman proceeds with his rarely-done leg of mutton, he throws out occasionally scraps of poisoned meat from a bag which he carries, and, as the dogs, attracted by the scent of the mutton, follow his trail, they come upon the poisoned fragments, and, eating them, they are killed off in short order. The wild dogs are not permitted to give much trouble in Australia. At first, on the new ranch, the sheep are driven to cover at night for safety, but after the tract is fenced the driving up at night is unnecessary. The fencing consists of wooden posts and wire. The posts are very durable, and as many as a hundred are cut and split out of one tree. There are men in the sheep-growing region who make a business of taking contracts for

FENCING IN LARGE TRACTS.

They have men and teams in great number in their employ, and put up miles of fencing with great rapidity. After the entire tract has been closed, it is divided into smaller parts of from 8,000 to 10,000 acres for large, and 4,000 to 5,000 acres for small paddocks. The fields are plowed and seeded with several varieties of English grasses, which grow in increasing strength and luxuriance as the sheep pasture becomes older. The first crop is of turnips, about seven ounces of seed being sown broadcast to the acre by a machine, which is followed by a chain harrow that covers it at once. With the turnip the grass seed is sown, the quantity of which varies according to the soil. The turnip crop is also varied, so that the soft, white root comes in first, followed by purple tops and swedes for use further along in winter. Sometimes wheat follows the turnip crop, and on poor lands will yield, after a season or two devoted to sheep pasturage, thirty to forty bushels to the acre. While feeding the turnips, a season which only continues for about three months in the winter, the patch is divided off into narrow strips across the field, upon which the sheep are kept till they eat the roots down pretty thoroughly, when they are moved up to another section. The mode of dividing

THE TURNIP PATCHES

is to put up a wire netting, which is made in England and costs about 12 cents a yard. It is rolled out across the field, and posts delivered at intervals along its length from a wagon. When the posts are on the ground, two men will put up a mile of netting in a day, which is a work somewhat like hanging up a seine to dry. The wire netting is tied fast to the posts. It is only a yard in width, but that is enough to keep the sheep from attempting to jump it. An American sheep grower suggested to Mr. McKellar that fencing is more difficult to obtain out on our plains than in Australia, and is, consequently, more expensive. The Australian, who has visited California, New Mexico, and Colorado, quickly replied, "You have coal and iron in abundance in Colorado, and you ought to be able to use iron posts and wire, and make the cheapest and best fencing in the world." American wool growers and woolen manufacturers have long been at war on

THE QUESTION OF WASHING.

Growers say it is a cruelty to both men and animals to require washing, and it is noticed that the sheep fall off very materially, even so far south as Ohio, where the streams are usually very cold up to shearing time. Mr. McKellar told how they wash in Australia and New Zealand. They construct large dips, in which the water is turned and kept up to a temperature of about 100 degrees Fahrenheit. Benches of battens are made just about the surface of the vat, upon which the sheep is held for washing. The fleece is thoroughly lathered, about 100 pounds of soap being used for 1,000 sheep. After the lathering, the sheep is removed to another table beneath a spout through which clear water flows, with the force created by a powerful pressure above. The water is led down in iron pipes to a sort of a trough about the length of a sheep; the lower edge of this trough is split, the opening of which can be regulated by screws to any required width. Upon a table beneath this spout the sheep are held and turned till thoroughly washed, when they are released and run into a clean paddock of English grass, with a "fleece as white," says Mr. McKellar, "as the driven snow." To day's washed are moved up one paddock to-morrow, and to-morrow's take their place, and so on for six days after the washing.

BEFORE THE SHEARING

The sixth day after the washing the sheep are taken into a shed, where sometimes thousands are found at a time, for shearing. As they are shorn, the fleeces are graded, the bellies, flanks, and ends being separated and thrown into screw presses, where they are baled for the London market. For hoof-rot troughs of about 35 feet in length, between paddocks, containing a solution consisting of about two ounces of arsenic to the gallon, are placed between the paddocks through which the sheep are driven, the water being deep enough to cover the hoofs of the animals. Sometimes a sheep will carry the sore hoof and run on three, to overcome which battens are placed across the trough, so as to compel the animals to put down all four in traveling through the solution.

SCAB IS CURED

by a dip composed of two ounces of sulphur and three of lime to the gallon of water, the sheep being driven in and compelled to wet their heads, also, by a bar under which they must swim. In this way ten men will wash 1,500 sheep per hour. A penalty by law of $500 for every case of scab found keeps the flocks clean.

In New Zealand the scab is totally eradicated. In Australia it is nearly so. Some inquiry was made as to the sheep found most profitable, about crosses, and

FINE AND COARSE WOOL.

Mr. McKellar said that for dry uplands the Spanish merino was found to be the best; for low, rich soils the long wool sheep Lincolns and Leicestershires are preferable. He observed that of the same breeds sheep in low condition produce the finest wool; those in high condition produce more wool, but it is of a coarser fiber. The Australians say that Southdowns do not by any means furnish the best mutton, nor does the feeding of turnips produce the most desirable meat. In the London market the black faced sheep of the Scotch Highlands and the Welsh mountains command the highest price for mutton. McKellar says that in eating that sort of mutton in England, he found that it was precisely like the best mountain grass-fed merino. Long wool sheep are not so good for mutton. On

THE QUESTION OF CROSSING

merino on cotswold and sheep of that grade, it was stated that the result invariably was to destroy both bloods, and produce a race of scrubs, precisely what farmers are trying to breed away from. It has been the dream of every young sheep grower to find perfection in mixing the blood of the short and long wools, in hopes of finding the happy medium of greatest good, but these experiments in America have invariably been followed by disaster, involving the depreciation of the flock. Mr. McKellar said such crossing had been found beneficial in the low, rich soil of Victoria, but it appeared on further questioning that it was only successful by grading in that locality away from the merinos and toward the Lincolns. There is no standstill in these respects. There may be a change from one to the other, but the half-way line cannot be maintained. In discussing the desirability of a

NATIONAL REGISTRY FOR FLOCKS

and individual sheep, Mr. Markham, of New York, said that the so-called "improved merino" are simply American merinos, which have been bred with great care, while the original flocks have been scattered. The importation of merinos to this country from Spain occurred from about 1802 to 1812, since which time they are found in a higher state of purity in this country than in Spain. For three hundred years before the Peninsular war the Spanish flocks had been tended with great care under the control of the government; not only were the separate breeds kept in all their pristine purity, but different families of the same breed were also kept carefully guarded from intermingling with each other. The Silesia and the French merino, as well as the American, all had their origin in those carefully guarded Spanish flocks. During the war subsequent to 1812, the Spanish flocks became separated, broken up, and mixed with others, so that they lost their high standard for breeding, and at this time the American merinos, which have been carefully tended, and are known to be descended from our first importations, are more valuable than sheep of that name imported from Spain to-day.

MANURES.

THE following letter of inquiry is received from a young farmer in Maine:

"I consider the *New England Farmer* a most reliable paper, and for that reason I wish to ask it a few questions. At the present time we have two horses and ten head of cattle, and their droppings are all cleaned into the barn cellar together, and a hog kept on them to prevent overheating. Will this manure waste by being hauled and spread upon ground where we intend to plant corn next spring? The field is quite moist, and on this account, and having more time now, we could haul it much cheaper than in spring. Our usual custom has been to haul and spread as near the time of plowing and planting as possible, and this is the course pursued by some of our neighbors, while others prefer to have manure spread some time before it is plowed in. What does science teach on this subject, and what experience and practice?

"I have seen it stated that burning bones did not destroy their value as fertilizer, with the exception of the nitrogen. Is it a fact, and if it is, what would be the value of one hundred pounds of bones burnt, compared with the same amount dissolved with sulphuric acid? I can obtain old, dry bones at fifty cents per hundred pounds; would they be a paying investment at that price?

"When stable manure is worth four dollars a cord, and shorts twenty dollars a ton, what proportion of their cost do I get back in the manure, if fed to dairy cows?

"YOUNG FARMER.

"Waterford, Me., December, 1880."

REMARKS—Science teaches that potash and phosphoric acid contained in stable manure do not rise and go off in the atmosphere, but that they are washed through the manure into the soil beneath as they become soluble. The same is true of nitrogen compounds during cold weather, and largely in any weather, except the manure be piled so as to heat, when the ammonia *may* escape into the air, although if plenty of absorbents are used, and the heating is not very violent, the loss in this direction is much less than many formerly supposed. If the land manured is on a very steep hillside, it is possible that the plant food as it is washed from the manure may be carried down the hill, although in practice it is rarely that much loss is sustained in this way from manure that is spread evenly over the ground. We have no hesitation whatever in recommending the drawing of stable manure directly from the yards to the fields where it is wanted from day to day during winter, and spreading it evenly over the ground or snow. We have practiced this method repeatedly, and have never had cause to regret it. If there were any loss from washing off the land, it has been more than balanced by the saving in expense of carting.

Old bones that have lost their nitrogenous material by age and decay are worth about the same before and after being burned. Burning makes them softer and more brittle, so they can be ground or pounded fine with comparatively little labor. Yet it must be remembered that, however thoroughly bones may be burned, they are not in consequence rendered soluble, and hence are not available plant food until they have been decomposed by the use of sulphuric acid or by rotting in the soil. In home practice, burning is not wasteful, as the loss is fully balanced by the saving of labor required in pounding or grinding raw bones. Whether you can afford to pay ten dollars per ton for such bones as will be brought to you, is a question we can not answer. Fine ground bone sells at from thirty to forty dollars per ton, and contains much less moisture than old bones that have been exposed to the weather. Bones dissolved in acid are ready for the plant, while burned bones require time according as they are coarsely or finely broken. If one has plenty of time to handle the bones himself, he will prob-

ably save money and get some pay for his labor in preparing them. If he is already fully occupied with paying work, it would probably be better to purchase the bones ready prepared.

It is impossible to state the exact value of the manure made from any given substance, so much depends upon circumstances—such as the crop to be grown, its value when grown, the skill of the grower, etc. Manure is worth much more applied to good than to poor land; it is worth more in a favorable season for growth than when the soil is either flooded or over-dried. Then, barn manure has no standard of value. It may be made from poor salt hay that will scarcely keep animals from starving, or it may be made from animals that are heavily fed upon good hay and grain. In Mr. Harris's "Talk on Manures," we find a table prepared several years ago by Dr. J. B. Lawes, giving the *relative* value of manure made from different foods. Here we find wheat bran is valued highly for what it is worth as manure, after passing through animals. Dr. Lawes bases the value of all manures on their contents in nitrogen, phosphoric acid, and potash at their market values. On this basis the manure from a ton of shorts is worth more than double that from a ton of good hay or a ton of corn meal. We give a few of his figures, which may be a guide in estimating relative if not actual values:

The manure from a ton of English hay he makes worth	$6 43
Clover hay	9 64
Wheat bran	14 59
Ship stuff	14 36
Corn meal	6 65
Potatoes	1 50
Carrots	80
Turnips, English	86
Turnips, Swedes	91
Beets	1 07
Oat straw	2 90
Wheat straw	2 68
Peas	13 38
Beans	15 75
Linseed cake	19 72
Cottonseed cake	27 83

Now, if this table is any guide whatever in determining the value of stable manure, it will be seen that to know how much one can pay for a given sample, he must know what the animals were fed on, and, also, whether they were idle, grown animals, or were young and working. The table supposes that the foods mentioned were all fed to a uniform class of animals, and that their relative value is thus determined. Dairy cows take much more from any food than idle oxen. Had your question been, "Can I afford to buy shorts at $20 per ton for feeding to dairy cows?" we should answer yes, if you can get your money back in the milk, and have the manure left as a waste product, but probably not if you have got to credit three-fourths the cost of the shorts to the manure pile.—*New England Farmer.*

APPLYING MANURE.

AT a meeting of the Woodstock, Conn., Farmers' Club, reported by the Southbridge *Journal*, Mr. C. H. May claimed that it is better to apply manure in the fall and winter to land to be planted the following year, than to wait till spring, as better results will follow, while the cost of carting will be considerably less.

Mr. Morse said he believed the best time to apply manure is when it can be done the cheapest.

Mr. Towne had experimented by drawing half his manure for a cornfield in the fall, and spreading it, and leaving the other half of the field to be manured in the spring just before planting. The result was decidedly in favor of the fall manured portion.

Mr. Law said he had laterally adopted the practice of carting manure to the field and spreading it as fast as made, and has better results than formerly. He does not think drying manure necessarily injures it.

Dr. Bowen related an experiment in planting corn on land manured only by herding sheep through the night. The crop was perfectly satisfactory, although the cost of manuring and labor account was small. He did not believe in hauling manure out into large piles to be again loaded and spread. It costs too much for labor.

A few of those present advocated spring manuring, but the majority were in favor of applying manure whenever convenient.

WISCONSIN FARMING.

A RETURN hither, after twenty-five years, shows an advancement in material prosperity beyond my most sanguine expectations. A short trip among farmers and visiting at their homes, will give one better ideas than much of the stuff written by that often imaginary person, "our special correspondent." At this time we have had no snow to speak of, only a sprinkling, as we say; but have had severe cold weather most of the time since November 20; still the cattle and sheep have been running in the fields every day, only being put into yards and barns at night. An eastern man is struck with the great scale on which farming is carried on.

I will relate some items gathered from a farmer who lives a few miles from here, with whom I spent a day, as probably a fair sample of the average farmer who has attended to his business. He is now sixty years old; came here thirty-four years ago with a wife and two children, and had $100, which he spent for eighty acres of unbroken land. He got trusted for breaking and sowing a part of it, and from the proceeds he got a team, and to-day owns 320 acres altogether, with a nice two-story house, and two large barns with basement cellars, besides grain barn, carriage house, hog house, and all necessary outbuildings; and another place in the village near by worth two thousand dollars. Keeps 23 cattle, 10 horses and colts, 200 sheep, 100 hogs, and poultry "too numerous to mention." He owes no man a dollar, and has money at interest; has always been a good liver. His farm is now valued at fifty dollars per acre. The present year he has raised 3,000 bushels of oats, 60 acres of corn, 120 bushels of wheat, 50 bushels of buckwheat, 150 bushels potatoes, 94 bushels of timothy seed, 50 tons of hay. He plows all his ground with a sulky plow; sows with a drill; plants with a corn-planter, 3½ feet apart each way. With a boy to drive the two horses, a man and boy will plant from fifteen to twenty acres a day. Soon after it is planted, he goes over it with a harrow, or drag, as it is called here, with sixty-two teeth about as long as your finger, which destroys the small weeds. When the corn is about three or four inches high it is again dragged. Again it is cultivated, and so the whole work is done by machinery.

After the ground is planted, one man will cultivate sixty or seventy acres with two horses. This man says, when the corn is glazed, he takes a portable fence and "takes up" ten acres, into which he turns one hundred spring pigs that will finish it up in a month. He then takes up another ten, and they finish that. The gain in that time is about 150 pounds each, which at four cents a pound makes $600 profit from twenty acres, with no trouble but to supply them with water and moving the fence.

When they husk corn, they drive the wagon astride a row, and husk that and two rows on each side. A man and boy twelve years old will husk one hundred bushels of cars a day, as they leave the small ears to be gleaned by the cattle with the fodder. The corn is mostly fed on the ear to horses and cattle. An average crop of corn is eighty bushels of cars to the acre; of wheat about fifteen; oats, fifty; potatoes, two hundred. The corn fodder usually stands till spring, when they take a railroad rail, and with a ring in each end, drag it across the field when the ground is frozen, in the direction they wish to plow, which enables them to bury every part of it, leaving it all right for a new crop. The straw is stacked and fed and trodden under foot to make manure, and in many cases burned.

The manure is drawn out in the fall, and plowed under. They frequently turn under a crop of clover to keep the soil up to required fertility. Nearly every farm has a windmill, which supplies the farm with water, and costs about $50. Timber grows very rapidly, and is mostly black oak, which seems to come up freely after the prairie fires. There is a great deal more wood in Dane county now than twenty-five years ago. The churches and schools are as well filled in this section as in the Eastern States, and the standard of education is as high.—*D., in New England Farmer.*

WASTE OF HORSE LIFE.

THE number of horses in the United Kingdom has been estimated at rather more than 2,250,000, and their average value can scarcely be set down at less than £30. Their collective value, therefore, falls little short of £28,000,000. That the nation incurs a loss if this sum is spent quicker than it needs to be is a self-evident proposition; that it is so spent is certain, if horses on an average become useless at a time when they ought still to be in full vigor. On this point few will be disposed to challenge the verdict of Mr. W. Douglas, late veterinary surgeon in the Tenth Hussars, who tells us that a horse should live from 35 to 40 years, and live actively and usefully three-fourths of this period. "All authorities," he says, "now admit that animals should live five times as long as it takes them to reach maturity. A dog, which is at its full growth when between 2 and 3 years old, is very aged at 12 years. Horses do not, unless their growth is forced, reach their prime until they are 7 or 8 years old, which, by the same law, leaves them to live some thirty years longer. When these facts are kept in mind, together with the other facts that three-fourths of our horses die or are destroyed under 12 years old, that horses are termed aged at 6 [he should have said 8], old at 10, very old when double that number of years, and that few of them but are laid up from work a dozen times a year, . . . the viciousness of a system which entails such misery and destruction of life can not be too strongly commented upon." If we take the age of 3 years as that at which horses begin to work, and 12 as that at which they are worn out, it follows that the period of their efficiency is shorter by at least 14 years than it should be. In other words, the nation has to buy three horses when it ought to buy only one, and thus upward of £200,000,000 are spent every twenty-one years in the purchase of horses, when £68,000,000 ought to suffice. The loss, therefore, to the nation at least is £135,000,000 in twenty-one years.—*Sir George W. Cox, in Fraser's Magazine.*

WHITEWOOD AND COTTONWOOD.

WHITEWOOD, *Liriodendron tulipifera*, sometimes known as the tulip tree and as yellow poplar, is a large tree reaching from seventy to one hundred feet in height, with a trunk four to seventy feet in diameter, and is one of the largest and most valuable trees of the Atlantic forests, being found from Vermont south to Florida and west to eastern Kansas. Its wood is light, close grained, strong, easily worked, and extensively used for construction, interior work, shingles, carriage panels, etc.

Another variety, the *Tilia americana*, otherwise known as the lime tree and as the basswood, is found from New Brunswick to the northern shores of Lake Superior, Manitoba, through the northern states to Virginia, along the Alleghany range to Georgia, and west to the Missouri River and Eastern Texas. Its wood is white, tough, pliable, and easily worked; is largely employed in interior work, turning, and the manufacture of wooden ware. It grows from sixty to eighty feet in height, and from three to four feet in diameter. It is very common in the forests of America. Still another variety, *T. pubescens*, is found from North Carolina to Florida, usually near the coast in swamps and low ground, and is a smaller species. Of the species, *Tiliæ*, we may also mention the variety, *Tilia heterophylla*, or white basswood, a medium sized tree, rarely exceeding fifty feet in height, found principally on the Alleghany mountains, from Pennsylvania to Georgia, and westward to the valley of the lower Wabash River. These comprise all the varieties of the whitewood as classified by the forestry department of the United States Government, which also marks as a distinct species several varieties of the poplar under the head of *Salicaceæ*. Of these we have the *Populus balsamifera*, the popular names of which are balsam poplar, tacamahac, and balm of Gilead found from the Mackenzie River and the Great Slave Lake, through British America, New England, and west to Wisconsin. This is a large tree, common in Arctic America, and claimed to furnish the bulk of the drift timber on the shores of the Arctic Sea. Then we have a variety classed as *Populus fremontii*, found in the valley of the Sacramento River, of California, and also in Nevada and Southern Utah; this is a large tree. The *Populus grandidentata*, found in Nova Scotia, New Brunswick, Canada, the Northern States, along the Alleghany range to North Carolina, and west to Wisconsin and Iowa, is rare at the South, but common at the North. Its wood is white, soft, and very light; it is extensively used in certain manufactures. It is a medium sized tree, reaching from seventy to eighty feet in height, with a trunk of twenty to thirty inches. The variety, *Populus heterophylla*, is found from Long Island, on the east, to the valley of the Ohio River, south to Cape Fear River, North Carolina, and Southern Arkansas. Its wood is soft and but slightly esteemed; it has a trunk thirty-six to forty-eight inches in diameter, and is usually found in swamps and river bottoms. The *Populus monilifera* is found from Western New England to the Rocky Mountains, and south to Florida and Louisiana. It is known as cottonwood, necklace poplar, and as Carolina poplar. Its wood is white and soft, and is of but little value. It grows to a height of eighty to one hundred feet, and has a trunk from four to eight feet in diameter. This is the common cottonwood of the western plains, and is found upon the borders of all the streams flowing east from the Rocky Mountains.

Another of this family, *Populus tremuloidus*, known as the American aspen or quaking ash, is more highly esteemed, having a white, soft wood which is easily worked; somewhat used in flooring and turnery, and in New England for paper making. It is found from Arctic America to Pennsylvania, New Mexico, and to the Sacramento River of California. It is common on all the northern ranges from the Rocky Mountains west and North, and in moist slopes and bottoms. It is the most widely distributed of any of the North American trees. This is probably the wood which is often classed with the whitewood proper, which it much resembles.—*N. W. Lumberman.*

ON RATIONAL SEASONING OF WOOD, ETC.

To the Editor of the Scientific American Supplement:

DEAR SIR—Misprints occur in your valuable journal extremely seldom; but in spite of all care they cannot be totally avoided. Now, it so happens that in the article published under the above heading in No. 272, vol. xi. (March 19, 1881), the word "not" was printed instead of "most," conveying the idea that David Stevenson found creosotized wood soon destroyed in places where the oily preparation was not abundant, instead of "most abundant." By inserting this correction in your next number, you will greatly oblige. SIGISMUND BEER.

New York, March 10, 1881.

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